THE
GEOLOGICAL MAGAZINE
VOLUME LXI.
No. II.—FEBRUARY, 1924.

OBITUARY.

The Rev. Professor T. G. Bonney, Sc.D., F.R.S., etc.

Thomas George Bonney was born on 27th July, 1833, at Rugeley, Staffordshire, the eldest of the ten children of the Rev. Thomas Bonney, of Pipe Ridware, near Rugeley. The family was of French Protestant origin, but had long been settled in Staffordshire. During his boyhood Thomas George Bonney showed an inclination towards natural science, which, indeed, seems to have been hereditary, as both parents were keen botanists. The years spent at Uppingham School helped to increase this taste, and provided facilities for fossil-collecting, thus awakening an instinct for geology. On leaving Uppingham as head of the School he went to St. John's College, Cambridge, where he soon obtained a scholarship. As was the custom of those days, he took both the mathematical and classical triposes, graduating in 1856 as twelfth wrangler with a second class in classics. Shortly after this his health partly broke down and he left Cambridge for a while, but a few months spent on the south coast and in the Alps restored him to health, and he accepted the post of mathematical master at Westminster School, while at the same time he prepared for holy orders, being ordained deacon in 1857 and priest in 1858.

In 1859 Mr. Bonney was elected to a fellowship at St. John's, and in 1861 he returned to Cambridge to take up the duties of junior dean, afterwards becoming tutor of his college. His principal work in Cambridge was done between 1861 and 1881, at which latter date he took up his residence in London. His regard for his college was shown by his return to Cambridge to spend the last years of his life.

Dr. Bonney was an ideal college tutor, "to his pupils he might be said to have given all he had; he helped them to the utmost of his powers, by lectures, private tuition, friendly advice, and informal teaching in the field." To all of them he was a true friend and the evening gatherings in his college rooms when undergraduates met many of the leading residents are still gratefully remembered by those who were privileged to be present. His geological pupils were specially favoured, and his influence is well shown by the recognition of St. John's as a college to which geological students have been and are specially attracted. During the years when the infirmities of old age were weighing on the Woodwardian Professor, Adam Sedgwick, Bonney's college lectures were the means of maintaining the traditions of the Cambridge School of Geology, and so continued during his tenure of his college lectureship. Among the members of his own college whom he taught were Teall, Sollas,

Jukes-Browne, Strahan, Clough, Milnes-Marshall, and Marr, while members of other colleges who studied under him included P. H. Carpenter, F. Maitland Balfour, and W. W. Watts.

In 1877 Dr. Bonney accepted the Professorship of Geology in University College, London, in addition to his work at St. John's. In 1881, on being appointed Secretary of the British Association, he quitted Cambridge, and went to live at Hampstead. To sum up his academic career, he retired from the Professorship in 1905 and returned to live in Cambridge. Though then over 70 years of age, his scientific career was still in full activity, and what may perhaps be regarded as its climax came in 1910, when he was elected President of the British Association for the Sheffield Meeting: his Presidential Address will long be remembered, both for its matter and its manner. Space will scarcely permit of an enumeration of the various offices held by Dr. Bonney, and of the academic and other distinctions showered upon him. Among them must be mentioned the following: Doctor of Science, Cambridge, Dublin, and Sheffield; Hon. LL.D., Montreal; Fellow and Vice-President of the Royal Society; Secretary and President of the Geological Society of London; President of the Mineralogical Society and of the Alpine Club; Whitehall Preacher, Hulsean Lecturer, Rede Lecturer, and Honorary Canon of Manchester.

Dr. Bonney's earliest publication seems to have been a contribution to that interminable subject, the study of palæolithic flint implements and the greater part of his writings, apart from theological publications, have reference to geology. It is a curious and perhaps instructive fact that Dr. Bonney apparently never attended any lectures on geology. This doubtless helps to account for the originality and independence of his outlook. As things were at Cambridge in his time, it fell to him to give lectures rather than to listen to them; in the special branch of the subject to which he at first devoted himself little was then known. It was only about 1859 that Henry Clifton Sorby, of Sheffield, prepared the first microscope-slide of a rock, and the pioneers of this great branch of geology were Zirkel and Rosenbusch in Germany, Allport, Clifton Ward, J. A. Phillips, and Bonney in England. The last-named was actually the first to publish technical descriptions of a vast number of the rocks of the British Isles, and he also described many specimens brought by travellers from the farthest regions of the earth. About 1875 a textbook of petrology was announced as being in preparation, but unfortunately it never appeared, probably owing to press of other work. The study of rocks, combined with a love of the Alps, naturally led Dr. Bonney to attack the problems of Alpine geology. He acquired an intimate personal acquaintance with almost the whole of the Alpine chains, and, indeed, he was one of the pioneers in Dauphiné. His conclusions as to the geology of certain parts of the Alps are founded on personal observation throughout a long life, and if not fully accepted by some of the Continental geologists, they

are, at any rate, worthy of most careful consideration. From the structure of the mountains, it was an easy transition to the study of ice-work in all its forms, and this subject, perhaps even more than petrology, occupied the later years of Dr. Bonney's geological life. The importance he attached to it is shown by the fact that he made it the principal theme of his presidential address to the British Association, which is a masterly summary of the evidence bearing on glacial problems, with special reference to those of the British Isles. In the great glacial controversy, as in many others, Dr. Bonney took the unpopular and unfashionable side, for the simple and characteristic reason that the popular views did not accord with his own observations on the spot. He was always the enemy of theorists and of cabinet geologists; his work was done in the open air, and the results recorded in a great array of notebooks, illustrated by his own vivid sketches. Then, when the matter was clear to himself, he proceeded to write out his results with a lucidity of exposition and a wealth of detail that left little loophole for doubt in the minds of readers as to what his own views were.

Besides a vast number of purely scientific and technical papers on geological subjects, the mere list of which occupies nearly six pages of small type in the GEOLOGICAL MAGAZINE, Dr. Bonney wrote several books of a more popular character, including *The Story of our Planet*, 1893; *Charles Lyell and Modern Geology*, 1895; *Ice-work*, 1896; *Volcanoes* (three editions); *The Building of the Alps*, 1912; *The Present Relations of Science and Religion*, 1913; four volumes of sermons, and several writings on Alpine subjects. At one period of his life he also contributed largely to the leading columns of a well-known daily paper since extinct. In 1921 there appeared a charmingly written little book entitled *Memories of a Long Life*, in which were set forth Dr. Bonney's reminiscences of early days at home and at school, of Cambridge and of travel and climbing, with a wealth of anecdote and many graphic sketches of the days now long gone by.

In spite of rather precarious health, Dr. Bonney was a man of marvellous activity, both mental and physical, and in his day a famous climber. Even after his retirement to Cambridge in 1905, he led a very active life, and when over 80 years of age he was able to spend long and strenuous days on the hills of Cumberland and Yorkshire, or scrambling about the steep cliffs of the Lizard. He also made frequent journeys to London to attend the meetings of the Geological Society, to Manchester to preach in the Cathedral, and to visit friends elsewhere. At this period also, so great was his love of teaching that he even found time to assist geological students in the Sedgwick Museum, where with unfailing patience he would spend hours in explaining small difficulties to a succession of inquirers, enlivening his discourse with witty illustration and caustic comment. Besides his own pupils in the old days at St. John's, now the masters of the science, Cambridge geologists of the younger generation owe much to Dr. Bonney.

ORIGINAL ARTICLES.

The Geology of the Aru Islands.

I. Introductory Note on the Relations of the Aru Islands. By J. W. Gregory, F.R.S.

II. Some Late Kainozoic Pelecypoda from the Aru Islands. By L. R. Cox, B.A., F.G.S., Geological Department, British Museum.

III. On Fossil Echinoidea from the Aru Islands. By Ethel D. Currie, B.Sc., Hunterian Museum, Glasgow.

I. INTRODUCTORY NOTE ON THE RELATIONS OF THE ARU ISLANDS.

By J. W. Gregory, F.R.S.

THE Aru Archipelago consists of a group of some eighty low islands which rise from the shallow sea between western New Guinea and Australia. They have been interpreted by Wichmann (1887, pp. 120–1) as the south-eastern members of an arc, to which he assigned also the Sula, Obi, and Misool Islands, and part of the south-western coast of New Guinea. This arc he regarded as the easternmost of three arcs at the eastern end of the Banda Sea. This view has been adopted, amongst others, by Koto (1899, p. 97, pl. i). The Aru Islands consist, according to the account in Verbeek's "Molukken Verslag" (1908, pp. 9, 464–5, fig. 420), of an almost horizontal limestone plateau, which has been broken by uplift into more than eighty pieces. These pieces he described as now partly bound together by coral limestone, and by banks of coral gravel which lie a little below the surface of the sea. The islands are separated by irregular winding salt-water canals, or trenches, which are known as "sungi". Their breadth is from 20 to 550 yards in the interior, and may be as much as two miles at their actual mouths. Wallace (1857, p. 479) regarded the sungi as valleys cut by rivers that rose in New Guinea, of which he considered the Aru Islands a detached fragment. The "sungi" are attributed by Verbeek to cracks that occurred in the sheet of limestone when it was raised above the sea, an idea previously suggested by Baron von Hoevell (1889) and Tissot von Patot (1908). Hugo Merton (1910, pp. 152–9) has adopted an intermediate position. He regards the main "sungi" as tectonic in origin, and thus explains the fact that they are in places considerably deeper below sea-level than any part of the adjacent sea floor. According to Merton (1910, p. 94) the depth of the Sungi Barkai is as much as 100 metres. The shallowness of some of the outlets may be due to shoaling; but in some cases this explanation is inapplicable, for at the eastern end of Sungi Manumbai, for example, the mouth is cut through rock and is only a few metres in depth. Merton regards the lateral sungi as old stream channels which have been enlarged by tidal erosion.

The rocks of the islands have been generally regarded as coral limestones of recent age. For example, Professor Brouwer[1] (1919, p. 415), mainly on the evidence of Verbeek's description, represents the island as composed of raised coral limestones. The Archipelago

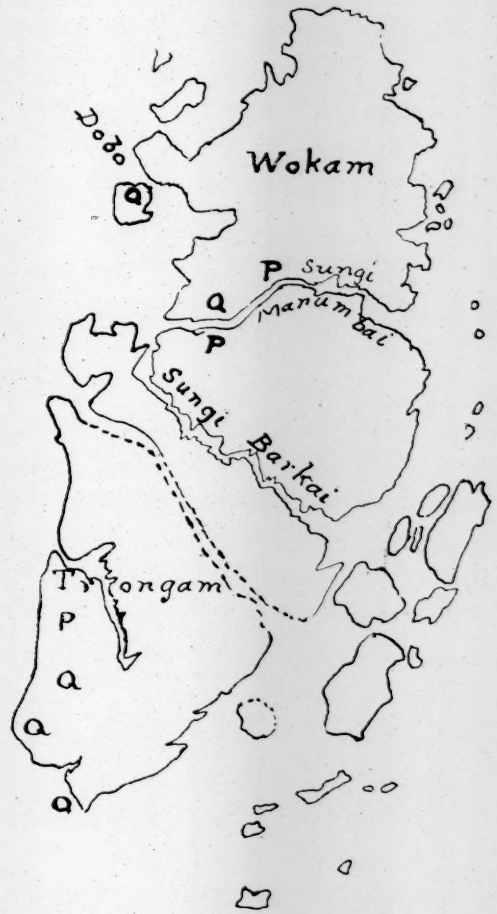


FIG. 1.—Map of Aru Islands with localities geologically determined. Scale 1 : 1,550,000. Q = Pleistocene, P = Pliocene or Miocene.

is marked as such on Abendanon's map (1914). They are described in the *Admiralty Pilot*, Eastern Archipelago Part III, South-Eastern Part (1911, p. 50) as "all . . . of coralline limestone"; but on

[1] Reference may be made to the two recent additions to Professor Brouwer's valuable contributions to the geology of the Eastern Archipelago, dealing with the adjacent Tenimber and Kei Archipelagoes, in *Jaarb. Mijnw. Ned. Oost. Ind.*, vol. I, 1923, pp. 117–68, 14 plates.

p. 183 the islands are said to be "for the most part of coralline limestone formation"; and it is stated that "along parts of the west coast coral is sporadic and there is very little stone formation" on parts of the archipelago.

The Aru Island limestones often contain quartz sand, but apparently few corals, as there appear to have been none in either the collections of Dr. Jensen or Dr. Merton. Dr. Jensen found some large Bryozoa, which have not yet been worked out; and they may have been seen by some earlier visitors to the island and have given rise to the view that the limestones contain many fossil corals.

That the islands contain rocks of a pre-Pleistocene age was reported by Ribbe in 1888. He referred some beds on the coast of Trangan to the Pliocene, but without stating the evidence for this view. That the islands contain some older deposits has been proved by Dr. Verbeek (1910), in his description of some rocks collected by Dr. Hugo Merton. The collection included some quartz sands and sandstones and unfossiliferous limestones, which are regarded by Dr. Verbeek as probably Pleistocene. In addition he found in a limestone from Marafenfen on the island of Trangan, *Lepidocyclina* and a *Baculogypsina* (better known as *Tinoporus*). The *Lepidocyclina* shows that the age of the limestone is probably Upper Miocene.

Döderlein (1911, pp. 238–9) in his account of the recent echinoids collected by Merton figured a fossil *Pecten* which Mr. Cox regards as probably *Pecten hulshofi*. Döderlein also described and figured a series of fossil echinoid spines, some of which he referred to the "Tertiar"; while some he regarded as probably Mesozoic from their resemblance to species found from the Trias to the Cretaceous. These spines are, however, regarded by Miss Currie as Upper Kainozoic and probably Pliocene.

Owing to the importance of determining the age of the rocks of these islands I asked Professor Mortensen—before knowing of Dr. Verbeek's note of 1910—whether he had obtained any evidence thereon during his expedition to the Moluccas. He kindly obtained from Professor J. P. J. Ravn, of the Mineralogical and Geological Museum of Copenhagen, the loan of a series of specimens collected on the Aru Islands by Dr. Hjalmar Jensen. The fossils were found in a sandy limestone, except the echinoid spines which occurred loose in sand at Sungi Waskai. There are no corals or coral rocks among the specimens sent to Glasgow. The specimens include fossil echinoids and mollusca and some Bryozoa which have not yet been worked out. The echinoids and molluscs have been identified and described in the accompanying papers by Miss Ethel Currie and Mr. L. R. Cox. Their determinations confirm Dr. Verbeek's conclusion that the islands include some pre-Pleistocene deposits. Once again in the geological history of the Eastern Archipelago, islands which were supposed to consist

of Pleistocene coral reefs contain a foundation of older rocks. The fossils collected by Dr. Jensen come from three localities: Manumbai; a sandy white limestone at Sungi Waskai, a branch from Sungi Maumbai or Manumbai; and some sandy deposits at Dobo on the northern coast of Wannar Island, from which the specimens were obtained loose. Whether the beds at the three localities belong to the same horizon is somewhat doubtful; the *Breynia*, which is perhaps the most reliable of the fossils as a guide to age suggests, as Miss Currie concludes, that the limestone is Pliocene. Mr. Cox considers the bed at Dobo as younger than that at the two other localities. Some of the echinoid spines from the Sungi Waskai and some of the mollusca from the same locality and from Manumbai render possible the Miocene age of the beds at those localities.

Dr. Jensen's collection is insufficient to prove definitely that both Miocene and Pliocene deposits are present in the islands. Seven species and one variety of molluscs are included in the collection. Of these two are only known Recent; two are not known living, and occur in both the Miocene and Pliocene; three of the species and the variety range from the Miocene to the Recent. Hence it seems advisable to refer the collection provisionally to the Pliocene. That horizon is consistent with the age of all the fossils.

The evidence of the echinoids is, as Miss Currie remarks, in favour of the Pliocene age of the deposits, for the echinoid spines are similar to those of the Pliocene deposits of the Mekran coast, and the *Breynia*, though a distinct variety, is closely allied to the living species, *B. australis*. Mr. Cox has determined among the mollusca from Manumbai *Ostrea djavanaensis* Martin; and he regards it as specifically identical with a fossil oyster found by Last in Zanzibar, which has been identified as *Lopha hyotiformis* (Philippi). He suggests that possibly some specimens collected by myself at Maunguja, near Mombasa, which have been identified as *L. virleti*, may also belong to the same species. This identification of the Zanzibar oyster is of great interest as helping to correlate the movements in East Africa with those of the Eastern Archipelago. The age of the Ostrea beds on Zanzibar and near Mombasa is, however, not precisely determined. Mr. R. B. Newton was prepared to admit the beds as Mio-Pliocene; and to include with them the crags at North Mombasa, which from the general evidence I thought it safer to classify as Pliocene (1921, p. 76).

The number of fossils from the Aru Islands is too few for any final opinion as to the precise age of its limestones. The evidence available indicates that the Aru Islands, and probably also part of the so-called "Recent" beds that cover a vast area in south-western New Guinea, were deposited during the widespread late Miocene and Pliocene advance of the Indian Ocean which formed the shelly crags in other parts of the Eastern Archipelago, along the coast of Baluchistan, and in East Africa.

There is no evidence available as to the strike of the limestones in the Aru Islands, and in the photographs by Merton the bedding of the rocks appears approximately horizontal. There appears to be no evidence from the island of any orogenic folding. The collection by Dr. Hjalmar Jensen sent to us does not contain any of the characteristic rocks of the Obi, Misool, or Sula Islands. It, therefore, gives no support to the view that they and the Aru Islands are part of one mountain arc. The geological relations of the Aru Islands are with the lowlands of south-western New Guinea, of which they doubtless represent a former extension.

REFERENCES.

Admiralty Pilot, 1911. *Eastern Archipelago*: Part III, South-eastern part, xxviii, 366 pp., 25 pls.

Brouwer, H. A., 1919. "Geologisch overzicht van het oostelijk gedeelte van den Oost-Indischen Archipel. Stratigrafie, Tektoniek, Vulkanisme": *Jaarb. Mijnw. Ned. Oost-Indie*, xlvi, pp. 145–452, 1 map, 3 profiles, 1 table, 16 photos.

Döderlein, L., 1911. "Über Echinoidea von den Aru-Inseln": *Abh. Senckenberg. Naturf. Ges.*, vol. xxxiv, pp. 237–48, pls. ix, x.

Gregory, J. W., 1921. *Rift Valleys and Geology of East Africa*, 479 pp., 25 plates and maps.

Gregory, J. W., 1923. "The Banda Arc: its Structure and Geographical Relations": *Geogr. Journ.*, vol. lxii, pp. 20–32.

Van Hoevell, G. W. C., 1890. "De Aroe-eilanden.": *Tijdschr. v. Ind. Taal, Land en Volkenk.*, xxxiii, pp. 57–101.

Koto, V., 1899. "On the Geologic Structure of the Malayan Archipelago": *Journ. Coll. Sci. Imperial Univ. Tokyo, Japan*, vol. xi, pp. 83–120, pl. i.

Merton, Hugo, 1910. "Ergebnisse einer zoologischen Forschungsreise in den sudöstlichen Molukken (Aru- und Kei-Inseln)": *Abh. Senckenberg. Naturf. Ges.*, xxxiii, 208 pp., 10 tables, 2 maps, and 60 figs.

Tissot v. Patot, J. W., 1908, "Een viertal tochten door het eiland Terangan (Aroe-eilanden)": *Tijdschr. K. Nederl. Aardrijksk. Gen.*, ser. II, xxv, pp. 77–93.

Verbeek, R. D. M., 1908. "Molukken-Verslag. Geologische verkenningstochten in het oostelijke gedeelte van den Nederlandsch Oost-Indischen Archipel.": *Jaarb. Mijnw. Ned. Oost-Indie*, vol. xxxvii, 826 pp., 10 pls.; also Atlas of 20 sheets.

Verbeek, R. D. M., 1910. "Bemerkungen über die von den Aru-Inseln mitgebrachten Gesteinsproben." In Merton, 1910, op. cit., pp. 206, 207.

Wallace, A. R., 1857. "On the Natural History of the Aru-Islands": *Ann. and Mag. of Nat. Hist.*, ser. II, vol. xx, No. 121, pp. 473–85.

Wichmann, A., 1887. "Gesteine von der Insel Kisser": *Jaarb. Mijnw. Ned. Oost-Ind.*, vol. xvi, pp. 104–22, pl. v.

II. SOME LATE KAINOZOIC PELECYPODA FROM THE ARU ISLANDS.

By L. R. Cox, B.A., F.G.S.

(*By Permission of the Trustees of the British Museum.*)

Ostrea djuvanaensis Martin.

1909. "Die Fossilien von Java": *Samml. geol. Reichs-Mus. Leiden, Neue Folge*, Bd. 1, Abt. 2, Heft 1, p. 334, pl. xlvi, figs. 1–4.

The general form acquired by an oyster is so dependent on environmental conditions that great care must be exercised in basing

specific distinction on any particular growth-tendency. The present species, the lower valve of which always possesses a small surface of attachment, is, however, marked by a tendency to acquire a very characteristic symmetrical, saddle-like shape. Both valves of the largest, best developed specimens are very thick, and approximately as long as high.

If the shell is regarded in its position of growth it is, as it were, folded downwards dorsally [1] and ventrally about its antero-posterior axis and at the same time folded upwards anteriorly and posteriorly about its dorso-ventral axis. In this way the ventral margin of the shell acquires a single U-shaped plication, while the anterior and posterior margins similarly acquire a ∩-shape.

Fig. 2.—*Ostrea djuranaensis* Martin. Manumbai. Showing saddle-like form. × ⅔.

The ligament region is large and obtusely triangular. In the largest specimen a tooth-like prominence exists at each of the lower angles of this area in the right valve, fitting into a corresponding socket in the lower valve.

Both valves are ornamented with irregular radial folds, affecting only the outer layers of the shell, which is not alectryonate. In places these folds become tubular, and may detach themselves to project as short spines.

The two specimens in the collection are of symmetrical growth. The smaller (length 7·5 cm., height 9 cm.) is moderately thin-shelled

[1] Actually the umbo of an *Ostrea* or *Pecten* is situated anteriorly with respect to the animal. For convenience, however, I use the terms dorsal, etc., in the same sense as for the normal pelecypod, i.e. umbones dorsal.

(depth of ligament region 1 cm. in each valve). The larger (11 by 11 cm.) is much thicker (depth of ligament region 3 cm. in each valve).

Locality.—Manumbai.

Previous Records.—Miocene of Java: Pliocene (?) of Ceram.

This species is allied to the widespread Upper Miocene *Ostrea virleti* Desh., from which it is distinguished by the growth-tendency described above. An incompletely developed specimen might well be confused with *virleti*.

In the late Kainozoic deposits of East Africa and Zanzibar a species of *Ostrea* is found to which Philippi has given the name *Ostrea hyotiformis* (*Zeits. d. D. geol. Ges.*, liii, 1901, p. 305). The actual specimen figured by him from near Dar-es-Salam does not show this particular feature very well, but the examination of a number of specimens now in the British Museum, collected by Mr. J. T. Last from the same horizon in Zanzibar, has disclosed the fact that this species also possesses the same growth-tendency as *djuvanaensis*, so that the largest specimens have the same characteristic form. They are also similar in their surface ornamentation and in the form of the ligament area.

It thus appears that these two species are to be regarded as identical, but distinct from *virleti*. Possibly they may prove ultimately to mark a definite geological horizon.

PECTEN (CHLAMYS) SENATORIUS Gmelin sp.

Ostrea senatoria Gmelin, 1790, *Linn. Syst. Nat.*, edit. xiii, p. 3327.

A full discussion of the synonymy of this species is given by Dautzenberg and Bavay in part lxiii of the *Siboga Expedition Monograph* (Leiden, 1912).

The collection contains one specimen which, although much eroded, is undoubtedly referable to the typical form of this species. Its dimensions are: height *c.* 8 cm., length *c.* 6·5 cm.

Locality.—Dobo.

PECTEN (CHLAMYS) sp. cf. SENATORIUS var. MINIACEA Lamarck.

Pecten miniaceus Lamarck, 1819, *Anim. s. vert.* vi, 1re. pt., p. 177.

Pecten miniaceus Reeve, *Conch. Icon.*, vol. viii, Pecten species 86.

I refer two small incomplete radially ribbed valves to this variety with considerable doubt, as the ears are missing. The dimensions of the more perfect specimen are: height 1·2 cm., length 0·9 cm. There are about thirty serrated closely-set ribs.

Locality.—Sungi Waskai.

Pecten senatorius is a species very variable in size and in the number and ornamentation of its ribs.

Present Distribution.—Indian Archipelago.

Fossil Records.—The work of Martin and others has shown that *senatorius* occurs fossil from the Lower Miocene onwards in the various islands of the Indian Archipelago, while closely related forms are known from the analogous deposits of Burma and Cutch.

PECTEN (CHLAMYS) cf. TJARINGINENSIS Martin.

1909. "Die Fossilien von Java": *Samml. geol. Reichs-Mus. Leiden, Neue Folge*, Bd. 1, Abt. 2, Heft 1, p. 351, pl. 1, figs. 54–6.

The collection contains several specimens of a *Pecten* very closely allied to those figured by Martin under this name, but differing in some respects, not of sufficient importance to warrant distinction as a new species.

I append a complete description: Shell equivalve; usually inequilateral, with posterior dorsal margin considerably longer than anterior. Some specimens, however, are almost equilateral. Slightly longer than high. Dimensions of largest specimen 3·5 by 3·2 cm. Each valve ornamented with about eighteen radiating ribs, the outer ones curving outwards. Interspaces about same width as ribs. Both ribs and interspaces semicircular in cross-section, so that margin of shell is regularly crenulate.

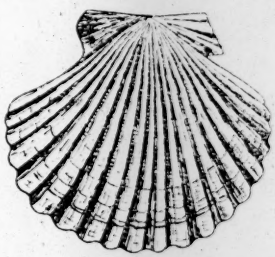


FIG. 3.—*Pecten* cf. *tjaringinensis* Martin. Manumbai. Right valve. Anterior ear broken. × 1.

On each valve both ribs and interspaces may be crossed by very fine concentric threads close together. The degree of ornamentation varies in different specimens. One left valve has all the ribs and interspaces so ornamented, another only every fourth rib, with the remaining ribs, as well as the interspaces, smooth. Other valves have all the ribs and interspaces unornamented; neither, apparently, is this due to erosion.

Posterior ears large, curving outwards from the disc with an S (right valve) or Ƨ (left valve) shaped border. Left with faint radial ribs crossed by concentric threads, right unornamented.

Right anterior ear narrow (not known complete), ornamented with about six radial ribs. Byssal notch not very deep. Ctenolium present. Left anterior ear narrow, concavely truncated.

Total length of hinge line just over half that of shell.

Internally well defined ribs, slightly concave in cross-section, correspond to the external interspaces, and extend from the margin about half-way to the umbo. Crural dentition well developed.

This species bears some resemblance to the Recent *tranquebaricus* Gmelin. The latter is, however, equilateral, with height exceeding length and with much larger anterior ears.

The present specimens differ from the types figured by Martin in their more inequilateral character, in their relatively greater elongation and in the shape of the posterior ears, which in Martin's specimens are obtusely triangular.

The Recent *P. fultoni* G. B. Sowerby, with which Martin compares *tjaringinensis*, has larger anterior ears and fewer, much more widely-spaced ribs.

Localities.—Sungi Waskai; Manumbai.

Previous record.—Miocene (?) and Pliocene of Java.

PECTEN (CHLAMYS) sp. cf. WILHELMINÆ Bavay.

1904. *Journ. de Conch.*, lii, p. 200, pl. vi, figs. 13–14.

The collection contains the upper portion of the left valve of a *Pecten*, which resembles the above more than any other described Recent species. While the ears and upper half of the valve are well preserved, the lower portion of the valve has, unfortunately, been broken off and lost. A study of the counterpart, however, gives some idea of the ornamentation of this part of the shell.

The approximate dimensions are: height, 3·0 cm.; length, 2·7 cm. The shell is slightly inequilateral, the posterior side being the longer. Its general proportions and also the shape of the ears are about the same as those of *cuneatus* Reeve. The ornamentation of the disc consists of numerous very faint radial striations, almost imperceptible near the umbones, but increasing in strength and developing into feebly pronounced, closely packed ribs before they reach the margin. The striæ are minutely serrated, especially in the neighbourhood of the anterior margin. The counterpart shows that the serration was more pronounced on all the ribs near the ventral margin.

Both ears are ornamented with about eight serrated radial striations.

The specimen resembles recent specimens of *cuneatus*. The main differences are a less prominent radial ornamentation and a difference in the serration of the ribs and striæ, which takes the form of a large number of small punctations instead of imbrications of the outer shell-layer overlapping ventrally. With the figure and description of *wilhelminæ* it agrees quite well, but is not perfect enough for certain identification.

Locality.—Manumbai.

Present distribution (of *wilhelminæ*).—New Caledonia and East Indies.

Fossil records.—No species with any close resemblance to the present form has hitherto been recorded fossil from the region in question.

PECTEN (AMUSSIUM) HULSHOFI Martin.

1909. "Die Fossilien von Java": *Samml. geol. Reichs-Mus. Leiden, Neue Folge*, Bd. 1, Abt. 2, Heft 1, p. 349, pl. xlix, figs. 46–9.

The collection contains several specimens (isolated valves), which

I refer to this species rather than to the related Recent species *P. pleuronectes*.

One distinction given by Martin is a difference in the colour ornamentation, the left valve possessing eleven or twelve broad dark sectors radiating from the umbo, instead of a much finer radial striation, while the right valve, instead of being unornamented, may have a fine radial striation near the umbo. The ornamentation of the specimens has only been very faintly preserved, but on one left valve the characteristic *hulshofi* pattern is discernible.

In addition the right valves are much more convex than in the case of *pleuronectes*. Externally the dorsal margins of the disc of the right valve are to a marked extent concave, so that these margins form shoulder-like angles with the anterior and posterior margins, instead of curving gradually round.

A distinctive feature which is very plainly observable in *hulshofi* is the much more massive character of the two lateral tooth-like prominences situated internally just below the ears.

Diameter of the largest specimen.—5·7 cm.

Localities.—Manumbai, Sungi Waskai.

Previous record.—Lower Miocene of Java.[1]

ANTIGONA SOWERBYI Deshayes sp.

Venus sowerbyi Deshayes, 1853 : *Proc. Zool. Soc.*, p. 2.
Venus sowerbyi Reeve, *Conch. Icon.*, vol. xiv, Venus species 24.

The specimen referred to this species is an internal cast agreeing very well in shape and proportions (length 7 cm., height 5·7 cm., thickness 4 cm.) with Deshayes' type specimen. A number of species (*sowerbyi, listeri, aegrota, lacerata*, etc.) closely related to *puerpera* Linn. have been described from the East Indies, but it seems doubtful if the specific distinctions drawn between all of them would be found to hold good on the examination of more material.

Locality.—Sungi Waskai.

Present distribution (of *puerpera* and allied species).—Indian Ocean and Eastern Asia.

Fossil records.—Martin refers specimens from the Lower Miocene of Java to the closely allied *listeri* Gray, from which *sowerbyi* differs only in being slightly less produced anteriorly.

From the Miocene of Cutch two species, *Venus cancellata* and *Venus granosa*, were described by J. de C. Sowerby. Of these Noetling records the latter from the Miocene of Burma, suggesting that it may be identical with the recent *sowerbyi*. Morley Davies (Geol. Soc. London, paper not yet published) records both from the Miocene of Ceylon. An examination of the type has led me to the opinion that *cancellata* should be considered identical with *puerpera* (typical

[1] Döderlein (*Abh. Senckenberg. Naturforsch. Ges.*, vol. xxxiv, 1911, pl. ix, fig. 9) depicts a fossil *Pecten* collected by Dr. Merton in the Aru Islands. The specimen is considerably obscured by adhering matrix, but appears to be referable to this species.

variety). The actual type specimen of *granosa* seems to have been compressed. Other Miocene specimens of this species agree well in shape and proportions with *sowerbyi*, but are all very much smaller than Recent specimens of the latter. I do not think that small differences in surface ornamentation are to be regarded as of systematic value in this group. On the whole, however, it seems best to continue to distinguish *granosa* from *sowerbyi*.

CLEMENTIA NON-SCRIPTA J. de C. Sowerby sp. var. ?

Venus non-scripta J. de C. Sowerby, 1840, *Trans. Geol. Soc.*, Ser. II, vol. v, pl. xxv, fig. 8.

Clementia papyracea Gray, 1847, *Proc. Zool. Soc.*, p. 184.

The identity of the fossil with the recent species having been established, it seems that Sowerby's name should have preference.

The specimen which I have referred to this very variable species is a cast differing considerably in shape from any other specimen that I have seen, being extremely elongated transversely.

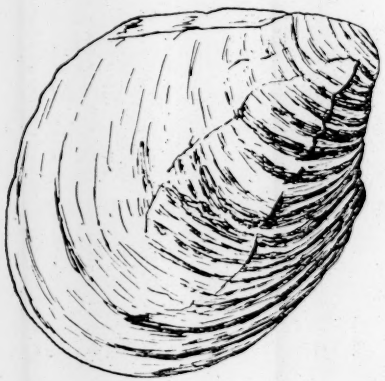


FIG. 4.—*Clementia non-scripta* (Sow.) var. (?). Sungi Waskai. × 1.

In the British Museum there are, however, specimens from the Kainozoic of Formosa intermediate in shape between the typical form and that now described. The cardinal margin is straight and approximately the same length as that of Sowerby's type. The escutcheon is limited by a fairly sharp carina on each valve. Anteriorly the shell has been distorted by pressure, and owing to this compression does not project, the umbones being terminal. The lunule has, however, not been entirely obliterated.

For the rest, the proportions of the specimen are considerably different from the normal form of the species (of which the length is usually about one and a half times the height). Actually the height (4·6 cm., measured perpendicularly to the cardinal margin) is approximately equal to the length (although this has been somewhat reduced by the compression anteriorly). The posterior margin forms

an obtuse angle with the cardinal margin and runs with only a slight convexity for a distance approximately equal to the length of the latter before curving round ventrally. The cast is ornamented with irregular concentric furrows most prominent near the umbones. The whole form is very reminiscent of a Chalk *Inoceramus*.

Locality.—Sungi Waskai.

Present distribution.—Australia; East Indies.

Fossil records.—Oligocene ?: Celebes. Miocene: Cutch, Burma, Java, Sumatra, East Africa. Pliocene: Timor. Kainozoic (exact age doubtful): Formosa, Japan.

Clementia ungeri Rolle, from the Miocene of Austria and Egypt, is probably identical with this species.

III. ON FOSSIL ECHINOIDEA FROM THE ARU ISLANDS.

By Ethel D. Currie, B.Sc., Hunterian Museum, Glasgow University.

(PLATE IV.)

The small collection of fossil echinoid remains here described was made by Dr. Hjalmar Jensen from the Aru Islands, a small group of islands lying off the west coast of New Guinea. The collection consists of the following:—

1. *Breynia australasiæ* var. *aroensis* n. var. (six specimens).
2. *Echinodiscus* cf. *auritus* Leske (one specimen).
3. A number of detached spines, chiefly of *Cidaris*.

The specimens of *Breynia* and the *Echinodiscus* are all from one locality, Dobo, and they are preserved in a friable brownish sandy limestone. The radioles or spines are from two localities, Manumbai and Sungi Waskai, and in both cases the matrix where any adheres is a soft white limestone.

I am greatly indebted to Professor J. W. Gregory, F.R.S., who not only gave me the opportunity of examining and reporting on the echinoids from the Aru Islands, but also helped greatly with his valuable opinion and suggestions. I am indebted also to Mr. L. D. Currie, who made the drawings of the spines for the figures.

Breynia australasiæ (Leach).

Spatangus australasiæ Leach, 1815. *Zool. Miscell.*, ii, p. 68, tab. 82.

Breynia crux andræ Agassiz, L., 1847. *C.R. Ann. Sci. Nat.*, (3), viii, p. 12, pl. xvi.

Breynia australasiæ Gray, 1851. *Ann. Mag. Nat. Hist.*, (2), vii, p. 131.

Breynia australasiæ Gray, 1855. *Cat. Rec. Ech.*, p. 46.

Breynia crux andræ Dujardin & Hupe, 1862. *Echinodermes*, p. 601.

Breynia australasiæ Agassiz, A., 1872–4. *Revis. of the Echini.*, p. 578, pl. xv*a*, figs. 7–9.

Breynia australasiæ Agassiz, A., 1873–6. *Report on the Echinoidea of the Challenger Expedition*, p. 177, pl. xxi, figs. 1 and 2.

Breynia australasiæ De Meijere, 1904. *Die Echinoidea der Siboga-Exped.*, p. 192.
Breynia desorii Gray, 1851. *Ann. Mag. Nat. Hist.*, (2), vii, p. 131.
Breynia desorii Gray, 1855. *Cat. Rec. Ech.*, p. 46.

BREYNIA AUSTRALASIÆ var. AROENSIS n.var.

Diagnosis.

A large *Breynia australasiæ* in which each tubercle-bearing interambulacrum (i.e. all except the unpaired posterior interambulacrum) bears four irregular rows of primary tubercles of slightly varying sizes, together with one solitary tubercle at the apex of the area. The first row consists of two or more rarely three tubercles. Number of tubercles in a lateral interambulacrum 26, in an anterior ambulacrum 19.

Material.—The collection includes six specimens of this species. They are all more or less abraded and broken, and they have evidently been taken from an exposed surface of the sandy limestone in which they occur, as, in each, a part at least of the upper surface of the test has suffered the effects of weathering. The upper surfaces of the tests are greatly abraded, and in most cases the fascioles obliterated. One specimen (No. 6), however, is fairly well preserved. It is slightly broken and flattened at the anterior end, but, as part of the upper surface was covered with the matrix, the internal and part of the peripetalous fascioles have been preserved and have been made apparent by the removal of the matrix.

Locality.—Dobo.

Affinities.—On studying the various descriptions and figures of the species referred to in the foregoing synonymy, one finds that the number of primary tubercles within the peripetalous fasciole varies greatly. In the original figure of Leach (1815) the number of the large tubercles in a lateral ambulacrum is 12 or 13, together with a number of smaller tubercles. Gray (1851 and 1855) describes *Br. australasiæ* as having *few* primary tubercles. He also distinguishes a species *Br. desorii* which has about 30 primary tubercles and is very like *Breynia australasiæ*. Agassiz (1872–4) regards this *Br. desorii* of Gray as synonymous with *Br. australasiæ*, although in his description of *Br. australasiæ* he says the number of tubercles in a lateral interambulacrum is from 8 to 10, as it is in his figured specimen. In all cases the tubercles appear to have no definite or regular arrangement.

The size of the test is another variable in specimens of the living *Breynia australasiæ*, as is apparent from the dimensions given in the *Revision* and in the reports of the *Challenger* and *Siboga* Expeditions.

	Length.	*Breadth.*	*Height in millimetres.*
Ag. *Revision* . . .	73	59	35
	63·5	53	31·5
Challenger Report . .	53	43	—
Siboga Report . .	40–60	—	—

It is most likely that the number of tubercles varies with the size

of the test, but I have not been able to verify this, as in most cases particulars of the dimensions, and the number of the tubercles are not both given.

The variety *aroensis* of *Breynia australasiæ* differs from the recent species in the two points in which the living specimens themselves are variable, namely in the size of the test and the number and arrangement of the primary tubercles within the peripetalous fasciole. In specimens of the variety, the dimensions of the test are much greater than those of the largest recent specimen recorded, and the six specimens of the variety under consideration are all approximately the same size. The dimensions of the best specimen (No. 6), which is slightly flattened, are: length 96 mm., breadth 83 mm., and height 41·5 mm.

In the number and arrangement of the tubercles, also, the variety *aroensis* differs from all figures of *Breynia australasiæ* (Leach). The tubercles are arranged in slightly irregular rows, and their number and arrangement is practically constant in the six specimens. In the Kainozoic species *Breynia carinata* and *Breynia magna* also, the tubercles have a somewhat similar arrangement in irregular rows. These specimens from the Aru Islands, being distinguishable from the recent *Breynia australasiæ* and being constant in character, might be regarded as a separate species, but considering the nature of the differences between them and the living forms I am disposed to consider them a variety of the species. Apart from its larger size, its greater number of tubercles, and their characteristic arrangement, the variety *aroensis* in other respects is apparently the same as the Recent *Br. australasiæ*. The Recent *Br. australasiæ* is only recorded from the regions of Australia, China, and Japan, in which area the Aru Islands lie.

Breynia carinata D'Arch. & Haime (*Pal. Indica*, Ser. xiv, "Foss. Ech. W. Sind," p. 343, pl. liv), which is most characteristic of the Miocene (Gaj Series) of Sind, is very like *Breynia australasiæ* var. *aroensis*. Indeed, at first sight, the specimens from the Aru Islands seemed identical with it, the arrangement of the tubercles in rows giving them a similar aspect. *Breynia carinata* differs, however, in being more elongated, in being more rostrated posteriorly and in the different shape of the internal fasciole, which is less drawn out to the posterior.

The fragment of a *Breynia* from the Kainozoic of Java figured by Herklots (*Fossiles de Java*, iv, *Ech.*, p. 13, pl. ii, fig. 7) as *Eupatagus magnus*, and afterwards referred to the genus *Breynia* by Martin (*Die Tertiarschichten auf Java*), probably represents a species near to *Breynia australasiæ* var. *aroensis*. Judging from the fragment the complete test must have been even larger and relatively greater in height than the *Breynia* from the Aru Islands. The fragment differs therefrom also in being thinner on the margin and in the peripetalous fasciole being farther from the edge of the test.

From its resemblance to the large species of *Breynia* of Kainozoic

times, *Breynia australasiæ* var. *aroensis* is probably an ancestral form of the recent *Breynia australasiæ*, and its age, therefore, must be late Kainozoic, probably Pliocene.

Figure.—No. 6.

ECHINODISCUS cf. AURITUS Leske.

Echinodiscus auritus Leske, 1778. *Klein. Add.*, p. 202.
Lobophora aurita Agassiz, L., 1841. *Mon. Scut.*, p. 70, pl. xiii and pl. xiv.
Lobophora aurita Agassiz, L., 1847. *C. R. Ann. Sci. Nat.*, (3), vii, p. 136.
Scutella bifissa Lamarck, 1816. *Anim. s. Vert.*, p. 10.
Lobophora bifissa Agassiz, L., 1841. *Mon. Scut.*, p. 67, pl. xiii and pl. xiv.
Lobophora bifissa Agassiz, L., 1847. *C. R. Ann. Sci. Nat.*, (3), vii, p. 136.
Echinodiscus auritus Agassiz, A., 1872–4. *Revis. of the Echini*, p. 531, pl. xiiic, figs. 1–3.

(For complete synonymy see Agassiz, *Revision of the Echini*.)

There is only one specimen (No. 7) of this large flat species in the collection, and unfortunately it is so fragmentary and the state of preservation of the fragments so poor as to preclude any certainty in its determination. The specimen is in six pieces, which, when fitted together, give one an idea of the configuration of the ambulacral petals, but the test is very incomplete, and the edge of the remains so smoothed that one cannot tell whether any of the original margin of the test is left or not. If one takes the farthest point of the specimen from the apical disc as the true edge of the test, one would estimate its length as between 180 and 200 mm.

The form of the ambulacral petals of the specimen is very like that of *Echinodiscus auritus* Leske, except that the petals are much larger than in that species. The petals are apparently almost all equal, and one posterior petal measures about 47 mm. in length, whereas the length of a posterior petal of the largest *E. auritus* of Agassiz (1872–4) is about 30 mm. In the same proportion the *Echinodiscus* from the Aru Islands ought to be about 240 mm. long.

A large incomplete *Echinodiscus* is recorded by Duncan and Sladen (*Pal. Indica*, Ser. XIV, "Foss. Ech. W. Sind.," etc., p. 381) from the Pliocene (Makrán Series) of Khárak Island, Persian Gulf. They regard it as a large variety of *E. auritus*, but give no dimensions or figures. It is quite probable that the specimen (No. 7) from the Aru Islands is a large *E. auritus* similar to that mentioned by Duncan and Sladen.

Locality.—Dobo.

Radioles.

The variety of form exhibited by the radioles or spines on the various parts of the same test in many recent species is apparently

very great, both as regards the shape of the radiole and the character of the ornamentation. Radioles quite different in shape and ornament may belong to one species, so that unless the different types have already been described from one species, one would more likely consider them as belonging to distinct species. It seems, therefore, a waste of time to give specific names to a number of unfamiliar detached spines. I have not attempted to do so in this report, but have merely arranged the radioles in groups of various types which I have compared so far as possible with fossil and recent species.

Goniocidaris sp.

One group of radioles (No. 16 (five specimens), No. 45, No. 40, and probably No. 44) no doubt belongs to the genus *Goniocidaris*. The radioles are all more or less incomplete, but they are evidently the same as, except that they are smaller, two of those figured by Duncan and Sladen (*Pal. Indica*, Ser. XIV, "Foss. Ech. W. Sind, etc.," pp. 373–4, pl. lvii, figs. 1–4) from the Pliocene (Makrán Series) of Henjam Island, Persian Gulf. Duncan and Sladen mention their likeness to spines of recent *Goniocidaris*, which is apparent on comparison with the figures of such a species as *Goniocidaris tubaria* (Lamk.) (Ag., *Revis. of the Echini*), but the *Goniocidaris* spines from the Aru Islands show much more resemblance to the Makrán than to the Recent spines. They differ from the Makrán spines only in their smaller size, which makes it probable that they also are of Pliocene age.

Specimen No. 40 from the Aru Islands is similar to the specimen of Duncan and Sladen of figs. 3 and 4 (op. cit., pl. lvii), and Nos. 16 and 45 are similar to their specimen of figs. 1 and 2.

Localities.—No. 16, Sungi Waskai; Nos. 40, 44, and 45, Manumbai.

Cidaris mertoni, Döderlein. *Abhand. Senckenberg. Naturforsch. Gesell.*, 1911, Band 43, Heft 2, "Über Echinoidea von den Aru-Inseln," p. 237, pl. ix, figs. 3–8.

The collection includes a group of radioles, all more or less different, which I refer to *Cidaris mertoni*, Döderlein. Only one of the specimens is identical with one of Döderlein's figures, but the others resemble in some degree his other figures, and considering the variations in the spines belonging to one species, I am disposed to regard the whole group as belonging to *C. mertoni*.

Specimen No. 23 from the Aru Islands is the same as the radiole figured by Döderlein on pl. ix, fig. 3 (ibid.). It agrees with Döderlein's figured specimen in every respect, except that it is smaller and its distal extremity is broken off so that it does not show the hollow with scalloped margin described by Döderlein. Like Döderlein's specimen, it is greatly flattened on the adoral face (ventral of Döderlein), and the spinulate ornamentation there is greatly reduced, which, together with its large size, indicates that the position of the radiole on the test was ambital or peripheral.

Another specimen, No. 17, is smaller than No. 23, but is very similar. It differs in its base being more contracted at the proximal end and the bilateral symmetry of the shaft being less marked. Its distal extremity also is broken off.

Dimensions.—

	Length.	*Greatest Breadth.*	*Greatest Thickness.*	*Diam. at annulus.*	*Diam. of proximal end of base.*
Döderlein, fig. 3	62	22	19	9·5	5
No. 23	53	21	18·5	9	5
No. 17	47	18	—	—	—

(The dimension called *thickness* is the distance between the adoral and adapical faces of the radiole. All measurements are in millimetres.)

Locality.—Nos. 23 and 17, Manumbai.

No. 12 is a small spine resembling somewhat the specimen figured by Döderlein on pl. ix, fig. 4 (ibid.). It is broken at both ends, but Döderlein's specimen is also incomplete. In general form they are the same, their greatest thickness being in the lower third, whence the shaft tapers to a point at the distal end. No. 12 is much smaller than the specimen of fig. 4, it is not so thick, and from its greatest thickness it tapers less rapidly. Except for these differences it appears to be the same.

No. 10 is a small radiole broken at its proximal extremity and with surface much worn. It is very like No. 12, but the shaft is not so strongly inflated and the spinulate ornamentation is not so strongly developed.

No. 9 is very similar to Nos. 10 and 12, but its shaft is even slimmer than that of No. 10, and although the surface is eroded, it is apparent that the spinules of the ornamentation are shorter and blunter. It is somewhat like the specimen of a young individual figured by Döderlein (ibid., fig. 8), but is larger and stouter.

These three spines (Nos. 9, 10, and 12) form a series in which the thickness of the shaft and the development of the spinulate ornamentation vary, and Döderlein's specimens of figs. 4 and 8 are evidently extreme forms of the series. In each member of the series one side of the shaft is slightly flatter than the other, and has less pronounced ornamentation.

Dimensions.—

	Length.	*Breadth.*
Döderlein, fig. 4	49	23·3
No. 12.	37	17
No. 10.	32·5	14
No. 9 ..	37	11·5
Döderlein, fig. 8	26	7

Locality.—Nos. 9, 10, and 12, Sungi Waskai.

Nos. 9, 10, and 12, being much thinner than the specimen of fig. 4 (ibid.), approach in general shape Nos. 17 and 23, but they are very much smaller, they taper to a point distally, and the spinules are not so large.

Nos. 9, 10, 12, 17, and 23 are somewhat similar to a group of radioles referred by D'Archiac and Haime to their *Cidaris halaensis* (*An. Foss. Num. de l'Inde*, p. 197, pl. xiii). Their specimen of fig. 3*a* (ibid., pl. xiii) is of the same type as Nos. 9, 10, and 12; their other figures are more like specimens Nos. 17 and 23. Spines of the same type have also been figured by Duncan and Sladen (*Pal. Indica*, Ser. XIV, "Foss. Ech. W. Sind, etc.," p. 285, pl. xlv) from the Miocene (Gaj Series) of Sind, but they doubt the determination as *C. halaensis*. They had a large variable series of radioles from Sind, in which they were able to link up by intermediate forms very extreme forms. They remarked on the great variability of the inflation of the shaft and the variability in the development of the spinulate ornamentation, variations which have already been noted in Nos. 9, 10, and 12 from the Aru Islands. None of the specimens from the Aru Islands agree exactly with any of the figured specimens of Duncan and Sladen, but their series undoubtedly includes forms of the same type as Nos. 17 and 23, but which are smaller and have less strongly developed ornamentation.

Another group of radioles which I refer to *C. mertoni*, and of which Nos. 26, 30, and 31 are examples, are of very striking appearance. They are more or less glandiform, the shape of the shaft recalling *Cidaris gibberula* Ag. of the Cretaceous, but their strongly developed spinulate ornamentation detracts from the resemblance. In most of the radioles the distal end is in the form of a shallow cup with fluted or scalloped margin, but one smaller specimen bears a ridge in place of the cup. Most of the radioles are bilaterally symmetrical, being flat and having reduced ornamentation on the adoral side. The spinules are large and prominent and irregularly arranged, and while some are sharply pointed, most are flattened and present a cutting edge instead of a point. There are eleven spines of this type, and they may be divided into two groups according to the shape of their proximal end. In one group the collerette is very broad and short, and in the other longer and very narrow. The acetabulum is the same size in both groups. These radioles are very like the specimen of *C. mertoni* from the Aru Islands figured by Döderlein on pl. ix, fig. 5 (op. cit.), but they differ in having the shallow cup with scalloped rim at the distal end, whereas in fig. 5 the shaft tapers to a point. Apart from this the resemblance is striking, as the specimen of fig. 5 has the flat knife-like spinules already described in these spines.

Dimensions.—

	Length.	*Greatest breadth.*	*Greatest thickness.*
Döderlein, fig. 5 . .	41	17·4	—
No. 30 . . .	30	16	15
No. 31 . . .	27	18	—
No. 29 . . .	44·5	25	23

Locality.—Nos. 13, 24–33, Manumbai.

No. 11, of which the proximal end is broken, is somewhat similar to the foregoing group, having the fluted cup at the distal end, but it differs in being almost cylindrical, the shaft tapering only very slightly towards the distal end. The adoral face has reduced ornamentation. It may be the same as the incomplete specimen figured by Döderlein on pl. ix, fig. 6 (ibid.), which he surmises occurred in the neighbourhood of the mouth. The specimen of fig. 6 is larger than No. 11, and the presence or absence of a distal cup is not mentioned.

Dimensions.—

Length.	*Breadth.*	*Thickness.*
31·5	13	11·5

Locality.—No. 11, Sungi Waskai.

One spine, No. 18, is a distinct type in itself. It does not resemble any of Döderlein's figures of *C. mertoni*, but it is at least convenient to leave it at present with that species. The shaft is only slightly inflated at the proximal end whence it tapers distally. The adoral face of the shaft is quite flat and in the proximal half is almost devoid of spinules, those present being very small. Except on the proximal part of the adoral face, spinulate ornamentation is very strongly developed, the spinules being very long and sharp and set comparatively far apart. The collerette is slightly broader than long, with almost parallel sides and the base is short.

Dimensions.—

Length.	*Greatest breadth.*	*Greatest thickness.*
41·5	14·5	12

Locality.—No. 18, Manumbai.

Whether all the spines referred above to *C. mertoni* actually belong to that species is not certain. Some of them certainly do, however, and it is probable that the others do also. Döderlein gives the age of *Cidaris mertoni* as Tertiary. He mentions also the possible Miocene age of some fossil foraminifera from the Aru Islands.

Figures.—Nos. 23, 9, 12, 11, and 18, Nos. 26 and 31 (with short and broad collerette), and No. 30 (with narrow collerette).

No. 20 is a massive tapering spine resembling somewhat certain species of recent *Phyllacanthus*. It is most like the radioles of an aberrant example of *Phyllacanthus baculosa* (Lamk.), figured in the report on the Echinoidea of the *Siboga* Expedition (pl. ii, fig. 9), but differs therefrom in the shaft being bilaterally symmetrical, the breadth being greater than the thickness, and the proximal end being slightly swollen. It is also very like those of *Ph. imperialis* (Ag., *Revis. of the Echini*, p. 391, pl. if, fig. 2), but in *Ph. imperialis* the shaft does not taper to the extremity but has a broad fluted tip. The shaft of No. 20 is marked by a fine granulation arranged in close

irregular longitudinal lines, which ends abruptly at a plain narrow band between shaft and collerette. The collerette is broader than long, the annulus prominent, the base short, and the acetabulum small and smooth.

No. 22 differs from No. 20 in the shape of the shaft, but in other respects is the same. The shaft is bilaterally symmetrical as in No. 20, but it does not taper uniformly. At a point about a quarter of the length of the shaft from its proximal end it contracts suddenly and then tapers gradually to the distal end. No 22 is better preserved than No. 20 (No. 20 being greatly abraded), and it is apparent that between the granules on the shaft there are numerous very minute granules, that the collerette is very finely striated, that the annulus is crenulated, and the base ends in a prominent ridge.

Another specimen (No. 21) is poorly preserved, but is evidently of the same species. The shaft is bilaterally symmetrical, as in Nos. 20 and 22; it is very broad at the proximal end, and then tapers gradually until just at the distal end it forms a knob.

Dimensions.—

	Length.	*Breadth.*	*Thickness.*
No. 20	55	11	10
No. 22	71	12·5	11·5
No. 21	65	16	14

Locality.—Nos. 20, 21, and 22, Manumbai.

Figures.—Nos. 20 and 22.

Nos. 8 and 15 show some resemblance to another type of spine of *Phyllacanthus baculosa* (Lamk.) (Ag., *Revis. of the Echini*, pl. ie, figs. 11–20), in which spinulate ornamentation is developed. In the figures of this type of *Ph. baculosa*, the shaft at the proximal end is somewhat inflated whence it tapers gradually distally, and the thorny spinules appear to be arranged in regular longitudinal series. Nos. 8 and 15 differ from these figures in the shaft being of uniform breadth and thickness, the thickness being less than the breadth, and in the arrangement of the spinules being irregular. No. 15 differs from No. 8 in some of the spinules being flat and plate-like instead of thorny. In both Nos. 8 and 15 the ornamentation is more strongly developed on one side (the adapical side) than on the other.

Localities.—No. 8, Sungi Waskai; No. 15, Manumbai.

Figure.—No. 8.

No. 41 resembles yet another type of spine of *Ph. baculosa* (Lamk.), viz. that figured by Agassiz in the *Revision of the Echini*, pl. if, figs. 4 and 5. No. 41 is a small, slender spine, with shaft covered with very fine granulation.

Nos. 42 and 43 are somewhat similar to No. 41, but the ornamentation on their shafts is much coarser and is more so on one side than on the other.

Nos. 46 and 47 have the same coarse granulation on the shaft, but they differ from Nos. 42 and 43 in being thinner at the junction

of shaft and collerette. The collerette is narrower, and contracts towards the distal end and the annulus is more prominent. They also somewhat resemble, although they are much smaller than it, the spine of *Cidaris rugata* of Herklots (*Fossiles de Java*, p. 3, pl. i, fig. 2), which later Martin (*Die Tertiarschichten auf Java*) referred to *Phyllacanthus baculosa* (Lamk.).

Locality.—Manumbai.

Figures.—Nos. 41, 42, and 46.

Nos. 34–5, 37–9 are small, cylindrical spines, with shafts covered with regular longitudinal series of fine granulation. The collerette is short and finely striated, and contracts distally. The annulus is very prominent, and crenulated, the base fairly deep, and wide, with fine striations. The spines of this type are not all exactly alike, the length of the collerette being slightly greater in some than others, and the thickness of the shaft varying slightly also.

No. 36 is very like the preceding five, but the granules of the ornamentation are slightly larger and the base is rather deeper. It is very like a spine figured by Duncan and Sladen (*Pal. Indica*, Ser. XIV, "Foss. Ech. W. Sind, etc.," pl. xlv, fig. 18) from the Miocene of Sind, which, they say, does not belong to *Cidaris*.

In general appearance the spines of this group are much alike, but the different relative dimensions of the collerette, base and shaft, are quite distinct.

Locality.—Manumbai.

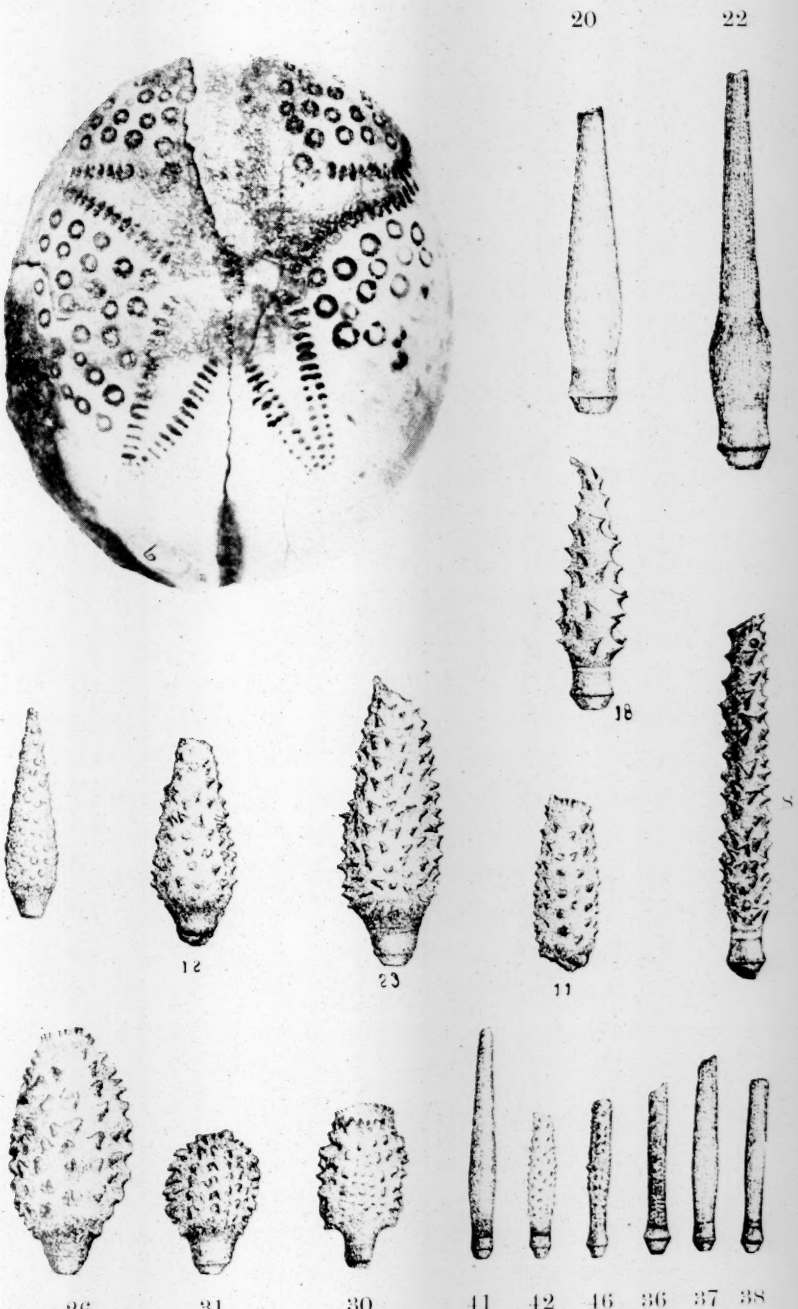
Figures.—Nos. 35, 37, and 36.

As regards the age of the beds from which the collection was made, the evidence of the echinoids is that they were laid down in Pliocene times. The evidence is not overwhelming, but considering everything, Pliocene seems to be the most probable age of both the sandy limestone at Dobo and the white limestone of Manumbai and Sungi Waskai.

The *Echinodiscus* is probably the same as the Pliocene variety of *E. auritus* mentioned by Duncan and Sladen, and the *Breynia australasiæ* var. *aroensis* as ancestor of the recent species is also probably of Pliocene age.

The *Goniocidaris* group of spines is almost certainly Pliocene. Of the remainder of the spines, some show resemblances to recent spines and others to spines of Miocene age, so that their evidence, although not positive, is not inconsistent with the conclusion that the beds are of Pliocene age.

Note.—In the figures all the radioles except No. 30 are drawn with the adapical face towards the artist. No. 30 is drawn from the adoral side.



Del. L. D. Currie. Photo D. N. Filshill.

FOSSIL ECHINOIDEA FROM THE ARU ISLANDS.

(To face p. 72.

On the Ammonites of the Speeton Clay and the Subdivisions of the Neocomian.

By L. F. Spath, D.Sc., F.G.S.

Contents.

I. Introduction.
II. Lists of Neocomian and Aptian Ammonites of Speeton, Lincs., and Norfolk.
III. Correlation Table. Subdivisions of the Neocomian.
IV. Summary of Conclusions.
V. Palæontological Notes.

I.

In some recent papers dealing with Tithonian ammonites, the writer [1] included zonal schemes of the higher Jurassic, up to what he considered the topmost horizon, namely the *privasensis* zone. The correlation of the Mediterranean ammonites with those of the "boreal province" or Pavlow's "Aquilonian" was also discussed. Since this author [2] had recorded "Aquilonian" *Craspedites* and *Garniericeras* from the Speeton Clay and Spilsby Sandstone, the inquiry naturally led to a revision of the ammonites of the Neocomian of Yorkshire and Lincolnshire. A critical examination of the ammonite horizons at the Jurasso-Cretaceous border-line seemed specially invited because in our most recent textbooks Yorkshire strata obviously well up in the Cretaceous are still included in the Jurassic; and it was also deemed useful to link up the table of Tithonian ammonite zones, above referred to, with that of the Aptian, given by the writer in a paper on the "Ammonite Horizons of the Gault and Contiguous Formations".[3]

By the courtesy of the authorities of many Public Museums and numerous private collectors, to all of whom grateful acknowledgements are here tendered, I have been able to examine a great number of ammonites of the Speeton Clay and of the Lower Cretaceous formations of Lincolnshire and Norfolk. With the aid of a grant from the Royal Society, I was also enabled to inspect the cliff-section at Speeton, and though the primary object of my visit, namely the uppermost beds, with the Gault, were very poorly exposed last year, the visit greatly increased my admiration for the zeal and labour embodied in the accounts and collections of my predecessors. The modern refinement in stratigraphical and palæontological nomenclature, and the additional knowledge of the last thirty years, necessitated a revision of the Speeton sequence; but this revision would have been impossible without the study of the splendid

[1] "Jurassic Ammonites from New Zealand": *Q.J.G.S.*, vol. lxxix, 1923. "On the Blake Collection of Ammonites from Kachh, India": *Mem. Geol. Surv. India, Pal. Indica*, 1923.

[2] In Pavlow and Lamplugh, *Argiles de Speeton*, Moscou, 1892, pp. 116, 117 (*Craspedites subditus* and *C. fragilis*). Pavlow, *Etudes sur les Couches Jurass. et Crét. de la Russie*, i, Moscou, 1889, pl. iv, figs. 6–8 (*Craspedites* cf. *subditus* and *Oxynoticeras catenulatum*).

[3] "Summary of Progress for 1922": *Geol. Surv.*, 1923, Appendix ii.

collections accumulated by Mr. C. G. Danford and Mr. G. W. Lamplugh, F.R.S. To the latter I am particularly indebted for continuously placing at my disposal his unrivalled knowledge of the succession, and, in the course of many discussions, both before and after my visit to Speeton, criticizing my views. The section, unfortunately, still represents the " huge mess ", so vividly described by Mr. Sheppard,[1] though, with sufficient patience, all the beds can be examined " in place ", on the hand of Mr. Lamplugh's excellent accounts.[2] If I follow Professor Judd [3] in pinning my faith to ammonites, not belemnites, it may be explained as the natural prejudice of a specialist. There may be a very marked change in the belemnite fauna at all the sectional boundaries, as Mr. Danford [4] stated, but even Stolley's [5] minute researches on the North German belemnite successions did not enable him to zone the Aptian of that country. For from an examination of my table of Aptian zones [6] it will be seen that the fauna of e.g. Ahaus is later than the *deshayesi* horizon (subzone of *Cheloniceras hambrovi* in Spath, p. 147) and earlier than the fauna with *Parahoplites schmidti* and *Sanmartinoceras* [7] *trautscholdi* (*aschiltaensis* subzone of my table). Nor did Stolley discover the absence, in North Germany, of probably the whole of the Lower and the lower part of the Upper Gault.

The lists of ammonites below, like the correlation table that follows, speak for themselves to those acquainted with ammonites and the classical Lower Cretaceous successions; but it may be advisable to summarize the more important points brought out in them for the general reader. It ought also to be mentioned that since the important successions of e.g. the South of France have not been zoned in sufficient detail, and since the identification of the French ammonites is too inaccurate for exact correlation, the table here given cannot be considered to be more than provisional. The palæontological notes at the end contain a revision of the ammonite nomenclature, notably of the Crioceratids.

II.

In the following lists of ammonites, those from Speeton are given in ascending order, i.e. from the lowest ammonitiferous bed

[1] " Notes on Some Speeton Clay Belemnites " : *Hull Mus. Public.*, No. 29, March, 1906, p. 1.

[2] " On the Subdivisions of the Speeton Clay " : *Q.J.G.S.*, vol. xlv, 1889, pp. 575–618. " On the Speeton Series in Yorks. and Lincs." : ib., vol. lii, 1896, pp. 179–220.

[3] " On the Speeton Clay " : *Q.J.G.S.*, vol. xxiv, 1868, pp. 218–50.

[4] " Notes on the Belemnites of the Speeton Clay " : *Trans. Hull Geol. Soc.*, vol. v, 1906, pt. i, p. 2.

[5] " Glied. d. Nordd. Unt. Kreide " : *Centralbl. f. Min.*, 1908, pp. 107 ff.

[6] Loc. cit., Summ. Progr. 1922, table on p. 147.

[7] *A. fontinalis*, Hudleston : Geol. Mag., 1890, p. 241, pl. ix, fig. 1, B.M. C. 5306, belongs to this keeled and costate Desmoceratid stock, quite distinct from the earlier *Aconeceras* Hyatt.

D_4 up to the top of B. The few Gault specimens known from Speeton are referred to in a later chapter (IV).

SPEETON.

D_4. (Near base.) *Polyptychites* aff. *lamplughi* Pavlow.

D_4. (Middle.) *Polyptychites* sp.n.? (aff. *beani* Danford,[1] xi, 4).

D_4. *Polyptychites* cf. *keyserlingi* (Neumayr & Uhlig) Pavlow (1892, v, 13). *P.* (*Dichotomites* ?) sp.n. ? ("*Craspedites fragilis*" Pavlow non Trautsch. sp.). *P.* (*D* ?) sp.n. ? ("*Craspedites fragilis*" Danford, xi, 1). *P.* (*D* ?) sp. ind. aff. id. *P.* (*D* ?) sp. juv.

D_{3-4}. *Polyptychites* aff. *michalskii* Bogoslowsky. *P.* aff. *rectangulatus* Bog. *P.* sp. ind.

D_3. *Polyptychites polyptychus* (Keys.) Bogosl. *P.* cf. *polyptychus* (Keys.) Bogosl. *P. cavaticus* (Bean MS.). *P. ramulicosta* Pavlow. *P. ramulicosta* Bogosl. non Pavl. *P.* (*Valanginites* ?) sp.n. (astieriform). *P.* (*Val.*?) aff. do. *P.* **pyritosus** sp.n. ("*lamplughi*," Pavlow, pars, viii, 1). *P.* cf. *michalskii* Bogosl. var. (xv, 6).[2] *P.* cf. *gravesiformis* Pavlow. *P.* aff. *subrectangulatus* Bogosl. ("aff. *beani*" in Danford, xi, 2). *P.* spp. juv. ind. *P.* (*Dichotomites*) sp.n. ? ("*fragilis*" Pavlow). *P.* (*D.*) sp.n. ? ("*fragilis*" Danford). *P.* (*D.*) spp. ind.

D_3. (Top.) *Polyptychites* cf. *keyserlingi* (Pavl. non Neum. & Uhlig).

D_{2-3}. *Polyptychites* cf. *michalskii* var. Bogosl. *P.* cf. *polyptychus* (Keys.) Bogosl.

D_2. (Base.) *Lyticoceras* aff. *planicosta* v. Koenen sp. *Olcostephanus* ("*Astieria*") sp. cf. *convolutus* Uhlig non v. Koenen.[3] *O.* (**Rogersites** ? [4]) cf. *convolutus* v. Koenen. *Polyptychites subgravesi* sp.n. (= "*keyserlingi*" Pavlow, ix, 1). *P.* cf. *sphæricus* v. Koenen (gigantic). *P. ramulicosta* Pavlow. *P.* aff. *polyptychus* (Keyserl.) Pavlow. *P.* **sublatissimus** sp.n. (= cf. "*keyserlingi*" Danford, x, 3). *P.* sp.n. (between *gravesiformis* Pavl. and *sublatissimus* nov.). *P.* (*Dichotomites* ?) spp. juv. ind. *Dichotomites beani* Pavlow. *D.* aff. *beani* Pavlow. *D.* sp.n. ? ("*beani*" Danford, xi, 5). *D.* **typicus** sp.n. (= "*polyptychus*" Danford, x, 2). *D.* aff. *grotriani* (Neum. & Uhlig). *Neocraspedites* [5] **speetonensis** n. (= "*bidichotomus*" Danford, x, 1).

D_2. *Hoplitides* aff. *submartini* Sayn (= "*heteroptychus*" Danford, xiv, 2). *H. heteroptychus* (Pavlow). *Lyticoceras* aff. *oxygonium* (Neum. & Uhlig). *L.* cf. *noricum* (Schloth.). *L.* **danfordi** sp.n. (Danford, xiii, 6). *L.* sp. ind., *noricus*-gp. (Danford, xiii, 5). *Distoloceras* **pavlowi** sp. nov. (= "*hystrix*" (Phill.) Pavlow, x, 10). *D.* cf. *spinosissimum* (Haussmann). *D.* cf. *roemeri* (Neum. & Uhlig). *D.* aff. *longinodum* (Neum. & Uhlig). *D. curvinodum* (Phill.). *Bochianites neocomiensis* (D'Orb.). *Polyptychites* cf. *multiplicatus* (Roem.) v. Koenen (iii, 4).[6] *P. sphæricus* v. Koenen. *P.* aff. *gravesiformis* Pavlow. *P.* **euryptychoides** sp.n. (sp. ind. E., Bogosl., xvi, 6). *P.* aff. *subgravesi* nov. *P.* sp. ind. *Dichotomites* aff. *beani* (Pavlow). *D. bidichotomus* (Leym.) Neum. & Uhlig sp. *D. bidichotomus* (Leym.) Pavlow sp. *D.* aff. id. *D.* sp.n. ? aff. "*Craspedites*" *fissuratus* v. Koenen.

[1] "Notes on the Speeton Ammonites": *Proc. Yorks Geol. Soc.* (N.S.), vol. xvi, 1906.

[2] "Mat. z. Kenntn. d. Untercret. Amm. Fauna, etc.": *Mém. Com. Géol. St. Petersb.* (N.S.), Livr. ii, 1902, p. 135.

[3] "Fauna of the Spiti Shales": *Mem. Geol. Surv. India, Pal. Indica*, ser. xv, Himalayan Foss., vol. iv, fasc. 2. 1910, pl. lxxviii.

[4] Gen. nov. (genotype: *R. modderensis* Kitchin sp.). See Pal. Notes below.

[5] Proposed (in "Ammon. Blake Coll. Kachh, India": loc. cit., 1923) for the *Craspedites*-like developments of *Dichotomites*. (Genotype: *N. semilævis* v. Koenen sp.).

[6] "Ammonitiden d. Nordd. Neocom.": *Abh. k. Preuss. Geol. L.A.*, N.F., Heft 24, 1902.

D. spp. ind. *Neocraspedites* aff. *semilavis* (Koenen). *N.* aff. *grotriani* (Neum. & Uhlig) Weerth sp. *N.* sp. nov. (? "*Craspedites*" *tenuis* v. Koenen).

D_1. *Hoplitides heteroptychus* (Pavlow). *H.* aff. *heteroptychus* (Pavlow). *Kilianella* ? **pexiptychoides** sp.n. ("*roubaudi*" Danford, xiii, 1). *K.* aff. id. ("*roubaudi*" Pavlow, pars.). *K.* cf. *leptosoma* (Uhlig). *Lyticoceras oxygonium* (Neum. & Uhlig). *L.* sp.n. ? aff. id. *L.* **stolleyi** sp.n. ("*neocomiensis* ?" v. Koenen, xxxi, 2, non D'Orb.). *L.* cf. *montanum* (Uhlig). *Leopoldia* ? sp. ind. *Distoloceras hystrix* (Phill.). *D. pavlowi* nov.

C_{11}. *Acanthodiscus* sp. ind. (*hookeri* group). *A. furcillatus* (Bean MS.). *A.* cf. *euthymi* (Pavlow non Pictet). *A.* sp. nov. ? *Lyticoceras* aff. *regale* (Bean MS.) Pavlow sp.

C_{10-11}. *Acanthodiscus* sp. ("*euthymi*" Danford, xiii, 8). *A. ebergensis* (Weerth). *A. bivirgatus* (Weerth). *Lyticoceras* aff. *regale* (Bean MS.) Pavlow sp.

C_{10}. *Lyticoceras regale* (Bean MS.) Pavl. sp. var. ("*oxygonius*" Danford, xiii, 3).

C_9. *Acanthodiscus ebergensis* (Weerth). *A.* aff. *ebergensis* (Weerth). *A.* aff. *bivirgatus* (Weerth). *A.* **confusus** sp.n. ("cf. *oxygonius*" Weerth, v, 4).[1] *A. munitus* (Bean MS.). *A.* sp.n. ? aff. id. *A.* aff. *furcillatus* (Bean MS.). *Lyticoceras regale* (Bean MS.) Pavlow sp. with var. *oxygonius* (Pavlow non Neum. & Uhlig) and var. *amblygonius* (Pavlow non Neum. & Uhlig). *Barremites* **subcassida** sp.nov. (="cf. *cassidoides*" Pavlow, xi, 19). *Subastieria*[2] ("*Astieria*") *sulcosa* (Pavlow). *Subastieria* ("*Astieria*") aff. *sulcosa* (Pavlow). *Subastieria* ("*Astieria*") **decipiens** sp. nov. (="*atherstoni*" Pavlow, x, 14). *Subastieria* ("*Astieria*") *trisulcosa* (Phillips). *Subastieria* ("*Astieria*") aff. id. (="? *spitiensis*" Danford, xi, 6). *Olcostephanus* ? ("*Astieria* ?") **subfilosus** sp.n. (="*astieri*" Pavlow, x, 15). *O.* ? ("*Astieria*" ?) aff. id. (="*astieri*" Danford, xi, 7).

C_8. *Acanthodiscus* **lamplughi** sp.n. ("*amblygonius*" Danford, xiii, 4). *Lyticoceras regale* (Bean MS.) Pavl. sp. *L. regale* var. *oxygonius* (Pavl. non Neum. & Uhlig). *L. regale* var. *amblygonius* (Pavl. non Neum. & Uhlig). *Barremites subcassida* nov. *Subastieria* ("*Astieria*") *sulcosa* (Pavlow). *Subastieria* ("*Astieria*") aff. *sulcosa* (Pavlow). *Olcosteph.* ? ("*Astieria* ?") *subfilosus* sp.n. *Parastieria*[3] *peltoceroides* (Pavlow). *Spitidiscus* **subrotula** sp.n. ("*rotula*" Phill. non Sowerby). *S.* **inflatiformis** sp.n. ("*rotula*" Pavlow, x, 12). **Speetoniceras**[4] *inversum* (M. Pavlow). *S. subinversum* (M. Pavlow). *S. versicolor* (Trautschold). *S.* **subbipliciforme** sp.n. (="? sp." Danford, pl. xii, fig. 3). *Simbirskites* ? *concinnus* (Phillips). **Ægocrioceras**[5] *intermedium* (Phillips). *Crioceras plicatile* (Phillips).

C_7. *Lyticoceras regale* (Bean MS.) Pavlow sp. *Subastieria* ("*Astieria*") *sulcosa* (Pavlow). *Subastieria* ("*Astieria*") sp. nov. ? *Spitidiscus* aff. *rotula* (Sow.). *Speetoniceras subinversum* (M. Pavlow). *S. subbipliciforme* nov. *Simbirskites* ? cf. *concinnus* (Phillips). *S.* cf. *elatus* v. Koenen non Trautschold sp. *S.* sp. juv. cf. *payeri* ? (Toula) Pavlow.

[1] "Fauna d. Neocomsandst. i. Teutob. W.": *Pal. Abh.*, vol. ii, 1884, pt. i.

[2] The genus *Subastieria* was proposed for this *sulcosus*-group in "Monograph of the Ammonoidea of the Gault", (Pal. Soc.), vol. for 1921 (1923), p. 32.

[3] The genus *Parastieria* for "*Acantoceras* (?)" *peltoceroides* Pavlow (1892, p. 152, pl. x, figs. 20, 21), obviously a derivative of the group of "*Astieria*" *sulcosa* Pavlow, was proposed by the writer in "Ammonite Horizons of the Gault and Contig. Format.": Summary Progress for 1922: *Geol. Surv.*, 1923, p. 144.

[4] Gen. nov. (genotype: *S. subbipliciforme* nov.). See Pal. Notes below.

[5] Gen. nov. for "*Crioceras*" *capricornu* (Roemer) Pavlow (1892, p. 154, pl. xi, fig. 9), differing from *Crioceras* s.s. (*duvali* group) in ornament and suture-line, but connected with it by such forms as *Æ. seeleyi* (Neum. & Uhlig).

C_7 (and C "lower to middle"). *Crioceras plicatile* (Phillips). *C. plicatile* (Bean MS., non Phillips). *C.* aff. *jurense* Kilian. *C.* aff. *nolani* Kilian. *C.* aff. *cornuelianum* (d'Orb.) = "cf. *matheroni*" Pavlow, xi, 10. *C.* sp. nov. ? (Neumayr & Uhlig, lvi, 3).[1] *C. beani* (Young & Bird = cf. "*Toxoceras*" *bituberculatum* d'Orb.). *C.* aff. *hildesiense*, v. Koenen. *C.* aff. *wermbteri* v. Koenen. *Ægocrioceras intermedium* (Phillips). *A. intermedium* (Bean MS., non Phillips). *A. raricostatum* (Phillips). *A. capitanei* (Bean MS.). *A.* sp.n. aff. id. (= "*puzosianum*" v. Koenen in Danford = *quadratum* (Bean MS., "var.")). *A. subnodosum* (Roemer). *A. cristatum* Pavlow non d'Orbigny sp. *A. quadratum* (Bean MS.) Crick sp. *A. semicinctum* (Roemer). *A.* cf. *semicinctum* (Roemer) [= *insigne* Pictet ?]. *A.* sp. nov. ? aff. *semicinctum* (Roemer). *A. ligatum* (Bean MS.). *A. seeleyi* (Neum. & Uhlig.) (typus, lii, 2). *A.* **subseeleyi** nov. (= *alternatus* Phillips, i, 27 non 26 = "*matheroni*" v. Koenen in Danford). *A. capricornu* (Roemer). *A. torulosum* (v. Koenen). *A. bucklandi* (Phillips) Buckland sp. *A. bucklandi* var. (Bean MS.) (less compressed). *A.* sp. nov.? aff. *intermedium* ("cf. *duvali*" v. Koenen in Danford). *A.* **koeneni** sp. nov. (= "*Ham. maximus*" Phillips, i, 21).[2] *A.* sp. nov.

C_6. *Spitidiscus rotula* (Sowerby). *S. youngi* (Young & Bird) [= "*cassidoides*" Danford, xiv, 6, non Pavlow]. *S. subrotula* nov. *Simbirskites venustus* (Phillips). *S. triplicatus* v. Koenen. *S. payeri* (Toula) Pavlow. *S. speetonensis* (Young & Bird). *S. progredicus* (Pavlow, 1892 non auct.). *Subsaynella* ("*Saynella*") sp.n. (group of "*S.*" *sayni* = cf. *carteroni* in Lamplugh, 1896, table, p. 184). *Crioceras* aff. sp. nov. ? jam. cit. (Neum. & Uhlig, lvi, 3). *Ægocrioceras* aff. *cristatum* (Pavlow non d'Orb.). *A.* aff. *capitanei* (Bean MS.).

C_5. *Spitidiscus rotula* (Sowerby). *Crioceras* sp. juv. (*wermbteri* group ?).

C_4. *Simbirskites* aff. *kleini* (Neum. & Uhlig) ("*decheni*" Pavlow, 1892, non Roemer, "*marginatus*" auct. non Neum. & Uhlig, "*nucleus*" auct. non Roemer). *S.* sp. ind. aff. *elatus* (Trautschold non M. Pavlow). *S. progredicus* (Lahusen). *S.* aff. *inverselobatus* (Neum. & Uhlig) Weerth sp. ("*umbonatus*" Danford, xii, 6). *S. trifurcatus* (Bean MS.). *S.* aff. *lippiacus* (Weerth). **Craspedodiscus**[3] *phillipsi* (Roemer). *C. gottschei* (v. Koenen). **Paracrioceras**[4] **statheri** sp. nov. (= "*beani*" Phillips, i, 28, non Young & B.).

C_3. *Simbirskites* aff. *inverselobatus* (Neum. & Uhlig) Weerth sp. (= "*umbonatus*" Danford, xii, 6). *S.* cf. *fasciato-falcatus* (Lahusen). *S. progredicus* (Lahusen). *S.* sp. ind. (large, *kleini*-group). *S.* aff. *pseudobarboti* (Pavlow). *S. marginatus* (Phillips). *Craspedodiscus* sp. ind. (large, *phillipsi*-group). *C. gottschei* (v. Koenen). *Paracrioceras* ? sp. juv. (Pavlow, xi, 11).

C_{2-3}. *Simbirskites* aff. *toensbergensis* (Weerth) (= "*decheni*" Danford non Roemer, xii, 7).

C_2. *Simbirskites* sp. juv. cf. *inverselobatus* (Neum. & Uhlig).

C_1. *Simbirskites progredicus* (Lahusen). *S.* cf. *progredicus* (Lahusen). *S.* sp. n. aff. *progredicus* (Lahusen). *S.* aff. *toensbergensis* (Weerth) (= "*umbonatus*" Pavlow). *S.* sp. ind. (*kleini*-group, large). *S.* aff. *fasciato-falcatus* (Lahusen). *Craspedodiscus* aff. *gottschei* (v. Koenen). *C.* cf. *discofalcatus* (Lahusen). *C. discofalcatus* (Lahusen). *C.* sp. ind.

[1] "Ammonitiden a.d. Hilsbild. Nordd.": *Palæontogr.*, vol. xxvii, 1881, Lief. 3–6.

[2] *Geology of Yorks*, 2nd ed., 1835, p. 95, pl. i, fig. 21 only (non 20 = *Hamites insignis* Pictet).

[3] Gen. nov. (genotype: *C. clypeiformis* Judd non d'Orbigny). See Pal. Notes below.

[4] Gen. nov., genotype: *Crioceras occultum* Seeley (*Ann. Mag. Nat. Hist.*, III, vol. xvi, 1865, p. 246, pl. x, fig. 1). (Sedgw. Mus.)

(*phillipsi*-group, large). *Paracrioceras statheri* nov. **Hoplocrioceras**[1] *fissicostatum* (Roemer) Neum. & Uhlig. *H.* aff. *læviusculum* (v. Koenen).

B (base). *Craspedodiscus* aff. *discofalcatus* (Lahusen). *C. carinatus* v. Koenen. *Paracrioceras statheri* nov. *P. bicarinatum* (Y. & B.). *Hoplocrioceras fissicostatum* (Roemer) Neum. & Uhlig sp.

B (lower). *Paracrioceras* aff. *occultum* (Seeley). *P.* sp. juv. *P.* aff. *varicosum* (v. Koenen = "*strombecki*" Danford). **Pseudocrioceras**[2] cf. *abichi* (Bač. Simon.) *Anthula* sp. *Hoplocrioceras* sp. nov. (Yorks. Mus.). *H.* aff. *fissicostatum* (Roemer). *H.* aff. *nodulosum* (v. Koenen).

B (probably Cement Beds and lower). *Paracrioceras* aff. *tuba* (v. Koenen). *P. banksi* (Bean MS.) (Sedgwick Mus.). *P.* sp. nov. ("*banksi*" Yorks. Mus.). *P.* aff. *denckmanni* (Müller). *P.* cf. *woeckeneri* (v. Koenen). *P.* aff. *elegans* (v. Koenen). *P.* sp. nov.? (Scarborough Mus.). *P. occultum* (Seeley). *P.* cf. *sexnodosum* (Roemer). *P.* cf. *gigas* (Roemer, non Sowerby). *Hoplocrioceras* cf. *læviusculum* (v. Koenen). *H.* cf. *fissicostatum* (Roemer). *H. aculeatum* (Bean MS.). *H.* sp. nov. (Scarborough Mus.).

B (Cement Beds). *Melchiorites* ("*Desmoceras*") cf. *charrierianum* (d'Orb.). *Pseudosaynella plana* (Phillips non Mantell). *Hoplocrioceras*? sp.

B (top and upper). *Callizoniceras*? ("*Desmoceras*") sp.n. (*hoyeri* group). *Pseudosaynella plana* (Phillips non Mantell). *Aconeceras nisoides* (Sarasin) v. Koenen and spp. juv. *Parahoplitoides fissicostatus* (Phillips). *P.* aff. *tenuicostatus* (v. Koenen). *P. bodei* (v. Koenen). *P.* sp.n. (*læviusculus* group). *Ancyloceras* sp.n. aff. *pingue* (v. Koenen). *A.*? sp. nov.?.[3] **Hemicrioceras**[4] sp. nov. (*rude* group). **Parancyloceras**[5] *bidentatum* (v. Koenen). *P. scalare* (v. Koenen). *P.*? sp.n. aff. *ægoceras* (v. Koenen). **Toxoceratoides**[6] *royeri* (d'Orb.) v. Koenen. *T.* aff. *royeri* (d'Orb.). *T.* cf. *plicatus* (v. Koenen). *T.* cf. *fustiformis* (v. Koenen, pars). *T. seminodosum* (Roemer). *T.* cf. *æquicingulatum* (v. Koenen). *T. rotundus* (Phillips, non *Helicoceras rotundum* Sowerby sp.). *T. rotundus* (Bean MS. non Phill.). *T. obliquatum* (Young & Bird). *T.* **sheppardi** sp. nov. ("*Ham. attenuatus*" Phillips, i, 25). *T.*? cf. *trispinosum* (v. Koenen, pars). *Leptoceras* cf. *parvulum* Uhlig.

Spilsby Sandstone.

A = Acre House; B = Bolingbroke; BH = Birken Hasen; C = Claxby; D = Donnington; G = Goulsby; H = Holton; N = North Willingham.

A, B, G, H, *Subcraspedites*[7] *plicomphalus* (Sowerby). B, *S.* sp. nov. (involute *plicomphalus*). B, *S. ptychomphalus* (Brown). C, *S.* aff. do.

[1] Gen. nov., genotype: *Ham. phillipsi* (Bean MS.) Phillips, *Geol. of Yorkshire*, pl. i, fig. 30, a form close to *Crioceras læviusculum* v. Koenen; to include also *Crioceras fissicostatum* (Roemer) Neum. & Uhlig, non v. Koenen?, and allied forms.

[2] Gen. nov., genotype: *Crioceras abichi* (Bač. Simon.) Anthula (*Beitr. Pal. Geol. Öst.-Ung.*, vol. xii, 1899, p. 124, pl. xii, fig. 1).

[3] A large fragment, resembling "*Heteroceras* sp. ind." in Haug, "Puez Alpe": *Beitr. Pal. Öst.-Ung.*, vol. vii, 1888, p. 222, pl. xiii, fig. 1.

[4] Gen. nov., genotype: *Crioceras rude* v. Koenen, 1902, loc. cit., p. 311, pl. xxxiv, fig. 1.

[5] Gen. nov., genotype: *Crioceras bidentatum* v. Koenen, 1902, p. 329, pl. xxxviii, figs. 1–3.

[6] Gen. nov., genotype: *Toxoceras royeri* (d'Orbigny) v. Koenen, 1902, p. 399, pl. xxxvii, figs. 7, 8.

[7] This genus (genotype: *Ammonites plicomphalus* Sowerby, *Min. Conchol.*, vol. iv, 1823, p. 145, pl. cccciv, non. pl. ccclix = *Ammonites ptychomphalus* Brown, 1889, emend. Spath) was proposed in "Blake Coll. Ammon. from Kachh, India": loc. cit., 1923.

D, *S.* sp. juv. BH, D, N, *S. stenomphalus* (Pavlow). B, *S.* sp. nov. (*pressulus*-like). H, *S.* sp. (*subpressulus*-like). A, B, *S.* sp.n. (*subditus* Pavlow non Trautschold). B, D, *S.* sp.n. (cf. *nodiger*, Pringle).

CLAXBY IRONSTONE.

A = Acre House ; BH = Benniworth Haven ; C and D, as above ; N = Normanby.

C, *Subcraspedites* aff. *subditus* (Pavlow non Trautschold). N, *S.* sp. ind. (aff. do.). D, *Polyptychites multiplicatus* (Pavlow non Roemer). D, *P.* sp. (*lamplughi*-group). BH, *P. ascendens* v. Koenen. BH, *P.* aff. *pyritosus* nov. BH, *P.* sp. ind. A, *P.* sp. juv. cf. *polyptychus* Pavlow non Keyserling sp. C, *P.* cf. *ramulicosta* Pavlow. BH, *Dichotomites* aff. *terscissus* v. Koenen. BH, *D.* spp. juv. BH, *D.* sp. ind. ("*obsoletecostatus*" Neum. & Uhlig). BH, *D.* sp. ind. (cf. *quadrifidus*, Bean MS., non v. Koenen). BH, *D.* cf. *beani* (Pavlow). A, *Neocraspedites* aff. *semilævis* (v. Koenen) and *carteroni* (d'Orbigny) Pictet sp. A, *Olcostephanus* ("*Astieria*") cf. *imbricatas* (Baumberger). A, *Lyticoceras* aff. *noricum* (Schlotheim). A, BH, *L.* sp. juv. A, *L.* cf. *oxygonium* (Neum. & Uhlig). D, "*Crioceras*" sp. ind. C, *Simbirskites* aff. *toensbergensis* (Weerth). C, *S.* aff. *fasciato-falcatus* (Lahusen).

TEALBY CLAY (Donnington).

Simbirskites aff. *kleini* (Neum. & Uhlig).

TEALBY CLAY (East Keal).

Dichotomites spp. juv.

TEALBY CLAY (Hundleby).

Polyptychites ramulicosta (Pavlow). *P. pyritosus* nov. *P. polyptychus* (Keyserling) Pavlow. *P. gravesiformis* (Pavlow).

TEALBY LIMESTONE.

Craspedodiscus barbotanus (Lahusen). *C. discofalcatus* (Lahusen). *C. phillipsi* (Roemer) Weerth sp. *C. bipinnatus* (Williamson MS.). *C. clypeiformis* (Judd non d'Orbigny). *Lytoceras* aff. *vogdti* Karakasch.

SNETTISHAM CLAY (Heacham).

Paracrioceras occultum (Seeley). *P.* aff. *varicosum* (v. Koenen = "*strombecki*" Danford non v. Koenen). *P.* sp. ind. *P.* cf. *elegans* (v. Koenen). *Acrioceras* cf. *tabarellii* (Astier). *A.* cf. *silesiacum* (Uhlig). *A.* ? sp. ind. *A.* ? sp. nov. ? *Hoplocrioceras* aff. *lævisculum* (v. Koenen).

CARSTONE (Hunstanton).

Parahoplitoides bodei (v. Koenen). *P. tenuicostatus* (v. Koenen). *P. lævisculus* (v. Koenen). *P. fissicostatus* (Phillips). *P.* spp. nov. *Stenhoplites* ? [Dufrenoyia] sp. nov. *Cheloniceras seminodosum* (Sinzow). *C. cornuelianum* (d'Orbigny). *C. albrechti-austriæ* (Hohenegger). *Ancyloceras* aff. *varians* (d'Orbigny). *A.* sp. nov. *A.* cf. *gracile* (Sinzow).

IV. SUMMARY OF CONCLUSIONS.

(1) The line at the base of the Cretaceous is drawn below the Spiticeratan age, but certain genera of the family *Spiticeratidæ* range lower. It is usual to include this age, as "Upper Berriasian", in the Cretaceous, and the "Lower Berriasian", which equals the Tithonian, in the Jurassic ; but to avoid confusion it seems preferable to use the term Infra-Valanginian for those early Cretaceous beds that are definitely below the (typical) horizons of the Calcaire Roux and Limonite of the Jura.

The position of *Subcraspedites* is somewhat doubtful. It is believed that the Russian Riasan beds with possibly derived Berriasellids of the Spiticeratan and Berriasellidan ages below,

represent a condensed deposit, like bed D_2 at Speeton or the Claxby Ironstone. Pavlow [1] thought he found eight species of these ammonites common to the Riasan beds and to what he called the "*stenomphalus* beds" of Alatyr, wrongly referred to the Platylenticeratan age; but both the "*Oxynoticeras*" and the "*Hoplites*" are new [2] and the writer suggested correlation of the latter with the *Hatchericeras* fauna of Patagonia.

It is customary to consider the *spasskensis* and *stenomphalus* zones boreal representatives of the (Mediterranean) *boissieri* zone, but it will be noticed that when truly contemporaneous beds are compared, the Mediterranean elements may be found in the "boreal" province (*Riasanites* and *Protacanthodiscus*, at Riasan, the Barremian *Lytoceras* aff. *vogdti* in the Tealby Limestone) and vice versa the "boreal" elements *Polyptychites*, etc., in southern deposits. It may be claimed that the sequence of events in Lower Cretaceous times is even now very incompletely known. Alpine-Mediterranean deposits, though often apparently homogeneous on account of marmorization and other changes, due to regional metamorphism, were probably formed under conditions of alternating deposition and penecontemporaneous erosion, just like their fragmentary equivalents of north-western Europe. The Neocomian succession of the South of France, as given in the accompanying table, almost certainly includes several gaps. Arguments based on a supposed relationship of successive ammonites are also generally worthless. There is no reason why the deposition of the zone of *Kilianella roubaudiana*, with Neocomitids, should not have been separated from that of the zone of *Thurmannites boissieri*, with the last *Berriasellidæ*, by a very long time interval; but the persistence, in southern sediments, of the fundamental genera *Phylloceras* and *Lytoceras*, from which were derived all the trachyostracous offshoots that migrated into more northern waters, gives the erroneous impression of continuity of deposition.

(2) The Speeton Clay does not represent a continuous succession from the Kimmeridgian to the Aptian. Resting on the Coprolite Bed (E) with derived Kimmeridgian ammonites of pre-"*pallasianus*" age, i.e. not of the uppermost Kimmeridgian, the lowest ammonitiferous beds at Speeton are already well up in the Valanginian and there is a complete absence of the uppermost Kimmeridgian, the whole of the Portlandian, the Tithonian (= Purbeckian), the Infra-Valanginian (= "Upper Berriasian"), and the lowest Valanginian formations. There is no trace even of the early *Polyptychites* (*brancoi* group) and the lower *Euryptychites* (*latissimus-diplotomus* group), of *Tolypeceras* (*marcoui* group) and

[1] "Le Crétacé Infér. de la Russie, etc.": *Nouv. Mém. Soc. Imper. Nat. Moscou*, vol. xvi, 1901, p. 39.

[2] New genera for these forms were proposed by the writer (*Q.J.G.S.*, vol. lxxix, 1923, p. 307).

III. CORRELATION TABLE.

Subdivisions of the Neocomian.

Stages.	Ages.	Zones.	Speeton.	Lincs. and Norfolk.	North Germany.	Russia.	South of France.	Other areas.
							Costid. recticostatus z.	Swinitza. Dj. Djaffa, Algeria.
Barremian.	Heteroceratan.	*pingue.*	Cement Beds.		×			
		innexum.			×			
		costellatum.			×			
		.....					*Heteroc. astierian.* z.	Wernsdorf and Gardenazza Beds. Dj. Djaffa, Algeria. Dj. Zaghuan, Tunis.
	Paracrioceratan.	*denckmanni.*			×			
		elegans.			×			
		roeveri.	Lower B.	Snettisham Clay.	×			Wernsdorf Beds, pars. S.E. Spain. Dj. Quach, Algeria. Venezuela. Trinidad. Colombia.
		.....					"*Crio.*" *emerici* z.	
Hauterivian.	Hoplocrioceratan.	*centrifuga.*			×			
		rarocinctum.			×		"*Hopl.*" *angulicostat.* z.	
		clypeiforme.		Tealby Lst.		*discofalcatus* zone.		
		discofalcatus.						*Toxaster* Beds ?
	Simbirskitan.	*progredicus.*	C_{1-3}	Tealby Clay (and Claxby) Ironstone ?).		*versicolor* zone.		
		phillipsi.	C_4		×			
		rotula.	C_5				"*Desmo.*" *sayni* z.	
		speetonensis.	C_6					
	Crioceratan.	*capitanei.*	C_7		×		*Crio. duvali* z.	
		capricornus.						
		.....						
	Lyticoceratan.	*sulcosus.*	C_8					
		regalis.	C_9					*Holcoptychites* and *pseudoregalis* Beds, Patagonia.
		ebergensis.	C_{10-11}		×			Derived blocks, Denmark.
		noricus.	D_{1-2}	Claxby Ironstone.	×			Rossfeld and Grodischt Beds. Haute rivian Marls. *Oosterella* Beds. Spain. "*Astieria*" Marls. Uitenhage Beds. *Valanginites* Beds, Colombia. "*Holcosteph.*" Beds, Mazapil and Spiti.
		radiatus.			×		*Acanthod. radiatus* z.	
Valanginian.	Hoplitidan.	*psilostoma.*			×			
		.....					*Saynoc. verrucos.* and *Kil. roubaud.* z.	
		heteroptychus.			×	*polyptychus* zone.		
	Polyptychitan.	*bidichotomus.*			×			
		terscissus.			×			
		ramulicosta.	D_3	Hundleby Clay.	×			Calcaire Roux and Limonite, Jura ?
		ascendens.	D_{4-6}		×	*keyserlingi* zone.		
		brancoi.	?		×			
		diplotomus.			×			Green Harbour and *C. Staratchin*, Spitsbergen.
	Platylenticeratan.	*marcoui.*			×			
		heteropleurum.			×	[*Nikitinoceras* Beds ?]	?	Up. Teschen [and Spiti ?] Shales.
		pseudograsianum.						"*Simbirskites*" of Crimea [and Knoxville Beds ?].
Infravalanginian.	Subcraspeditan.	*stenomphalum.*		Spilsby Sdst.	"Wealden"	*Subcraspedites* beds.		"Craspedites" of *C. Staratchin*, Spitsbergen.
		tolli.						
		spasskensis.						
	Spiticeratan.	*lation.*					*Thurmann. boissieri* z.	*Spiticeras* zones of Patagonia. *Substeueroceras koeneni* z. of Patagonia. Spiti Shales of Himalayas.
		damesi.						
		acutum.					"*Berr.*" *callistoides* z.	

[To face p. 80.

Platylenticeras (*gevrilianus-heteropleurus* group), but the few feet of clay below the pale beds (D_6) have not yielded ammonites.[1]

The term "Passage Beds" for the lower division of the Speeton Clay, as used on the Geological 1 inch map (sheet No. 55, N.S.), is thus inadmissable.

(3) The Spilsby sandstone is not of "Upper Volgian" or "Aquilonian" (Jurassic) age and contains neither *Craspedites*[2] nor *Garniericeras*,[3] but ammonites older than any found in the Speeton Clay. There is a general resemblance of these to the "*Craspedites*" of the Riasan beds of Russia, but the Lincolnshire species are probably not identical and certainly much later than the true "Aquilonian" *Craspedites*.

(4) The specimens from bed D_4, generally misidentified with *Craspedites* and *Garniericeras*, are young *Polyptychites* (and *Dichotomites* ?) as suggested by v. Koenen[4] more than twenty years ago, though this author also described similar immature forms from ferruginous nodules in the "*oxynotus*" bed (*marcoui-heteropleurus* zones). At Speeton they are associated with forms referable to the comparatively late *ascendens* zone.

(5) The common drift specimens of Speeton *Polyptychites*, e.g. of the Holderness coast, come from an equivalent of the *ramulicosta* and *ascendens* zones (D_3 and D_4) at Speeton, and are now found in situ in a similar mode of preservation only in the "Tealby Clay" of Hundleby, Lincs. A specimen of *Polyptychites* cf. *triplodyptychus* Pavlow, from Culgower, Scotland, in the British Museum (No. C. 13209) is probably from beds of the same age.

(6) There is another (local ?) gap in the succession at the top of the Valanginian. Ammonites of the uppermost horizons, e.g. *bidichotomus*, *heteroptychus*, and *psilostoma*, and of the lowest Hauterivian *radiatus* zone, i.e. the faunas of Baumberger's[5] *Astieria* Marls and Hauterivian Marls, occur derived in the black nodules of bed D_2, but are associated already with *Lyticoceras noricum* and allies.

The Claxby Ironstone of Lincolnshire, also containing true "*Astieria*", seems to represent a similar mixed deposit, with derived

[1] The cast, on an *Exogyra*, of part of a large ammonite, recorded by Mr. Lamplugh (*Q.J.G.S.*, 1896, p. 200, footnote 3), was stated to be insufficient for specific determination, but possibly "akin to the *Craspedites* group of *Olcostephani*". It shows that curious backward bend of the costæ on the umbilical slope, found in many large *Polyptychites* of the *brancoi* group, but is unfortunately quite indeterminable.

[2] J. Pringle, "Pal. Notes on the Donnington Borehole of 1917": *Summary of Progress, Geol. Surv. for* 1918 (1919), Appendix iii, p. 50.

[3] Salfeld, "Glied. d. Ob. Jura in N.W. Europa": *N.J. f. Min.*, Beil.-Bd. xxxvii, 1914, table to p. 128, evidently in error, quotes "*Platylenticeras caletanum*".

[4] "Ammonitiden d. Nordd. Neocom.": *Abh. k. Preuss. Geol. L.A.*, etc., N.F., Heft 24, 1902, p. 440.

[5] "Ammonitiden d. Unt. Kreide im W. Schweiz. Jura," pt. vi: *Abh. Schweiz. Pal. Ges.*, vol. xxxvi, 1910, pp. 41–5.

ammonites of the Hundleby Clay and Spilsby Sandstone on which it rests non-sequentially. But the youngest forms there are *Simbirskites*, so that it is presumed to include two deposits of different dates, the lower corresponding to bed D_2 at Speeton, the higher to the *phillipsi* zone of the Hauterivian; but there is no evidence as to the position of the fossils in the few feet of Ironstone and as to whether the two *Simbirskites* (in the Sedgwick Museum) came from the clayey band at the top of the Ironstone.[1]

(7) The true *Ammonites noricus* occurs only at the extreme base of the "*noricus* zone" of Professor Judd, having its maximum occurrence at about one foot above the nodules of bed D_1. The ammonite generally misnamed "*A. noricus*" is *Lyticoceras regale*, with its maximum in bed C_9, but occurring already in C_{11} and C_{10} and gradually dying out in beds C_8 and C_7. The advantage of using only the smallest units for correlation is evident; for in North Germany there is apparently a local gap between the *ebergensis* and *capricornu* horizons, or at least a less complete sequence.

(8) The Crioceratan age may include the *duvali* zone of Southern France; for pyritized *Simbirskites* comparable to forms of C_6 occur at Barrème, Basses-Alpes (B.M. No. 73463, Astier Coll.), above the *duvali* beds, but appear to be missing in most Mediterranean areas. The Spiti *Simbirskites* described by Uhlig,[2] Burckhardt's[3] *Simbirskites mexicanus*, and Douvillé's [4] Argentine species, probably also Karakasch's *S. auerbachi* (Eichw.),[5] have been misidentified generically; but a form of the group of "*Saynella*" *sayni* has been found in the Simbirskitan bed C_5 at Speeton.[6]

(9) The Tealby Clay (of Donnington, etc.) represents the *progredicus* zone, and the Tealby Limestone the *discofalcatus* and *clypeiformis* zones. After the Tealby Limestone follows another unconformity in Lincolnshire; and a break in the North German succession is indicated by the sandy *rarocinctus* bed.

(10) *Hoplocrioceras* of the type of *H. fissocostatum* (Römer) Neumayr and Uhlig (non v. Koenen and Stolley ?) occur in the top beds of C and the base of B, but the correlation with the somewhat similar *Pseudothurmannia* ("*Crioceras*") *angulicostata* (d'Orbigny) Pictet sp. is quite tentative.

(11) The *Paracrioceras* of the *roeveri* and *elegans* zones resemble, but are not identical with, those of the *emerici-barremense* group of

[1] Lamplugh, loc. cit., 1896, p. 201.

[2] "Fauna of the Spiti Shales": loc. cit., fasc. ii, 1910, pl. xlv A, fig. 1.

[3] "Faunes Jurass. & Crét. de San Pedro del Gallo": *Bol. Inst. Geol. Mexico*, vol. xxix, 1912, p. 129, pl. xxxiv, figs. 18, 19, 21, 22.

[4] "Céphalop. Argentins": *Mém. Soc. Géol. France*, Pal. No. 43, 1910, pl. xix, figs. 3, 4.

[5] "Le Crétacé Infér. de la Crimée, etc.": *Trav. Soc. Imp. Nat. St. Pétersb.*, vol. xxxii, 1907, p. 130, pl. xiii, figs. 1–5.

[6] Lamplugh Coll., labelled "probably C_6" and recorded (loc. cit., 1896, table, p. 184) as *Olcostephanus* (*Simbirskites*) cf. *carteroni* d'Orb. (Professor Pavlow's identification).

the South of France. On the other hand, in the corresponding Snettisham Clay, *Acrioceras* of the group of *A. tabarellii* (Astier) and *A. silesiacum* (Uhlig) have been found associated with these *Paracrioceras*. The Barremian at Speeton, as probably at any other single locality, is very incomplete, and even if bed B be found to include all the zones of the North German succession, there must be some gaps. There is no trace of the Astieridiscan, Pulchellian, Heinzian, and Heteroceratan faunas, all of which include " hoplitid " or trachyostracous developments that are unknown in the North, but probably not on account of climatic differences.

The insertion of the Barremian faunas in the table is thus provisional. The " *Crioceras* " zones here given almost certainly represent only a small proportion of (ideal) Barremian time, and the gaps in the table may have been placed at incorrect levels.

(12) The *pingue* zone, in which *Pseudocrioceras* (and in Germany *Barremites* and *Holcodiscus*) have been found, is doubtfully classed as the highest Barremian (Heteroceratan ?) and is followed by the Parancyloceratan age given in a previous table.[1]

(13) The lower Aptian black clays, forming the top of B, and having *Parahoplitoides fissicostatus* of the *bodei* zone above and *Aconeceras* and *Parancycloceras bidentatum* below, are not immediately overlain by the Albian clays of the *cristatus-orbignyi* zones, from which *Anahoplites trifidus* Spath (W. C. Hey Coll., Yorkshire Museum) probably was collected. There are intermediate beds of greater thickness than originally observed by Mr. Lamplugh[2]; and Mr. Stather once measured a section with five feet of these " *ewaldi* " clays below the Gault. The Middle and Lower Albian fossils examined by the writer are *Hoplites* cf. *dentatus* (Sowerby), *Leymeriella* cf. *hitzeli* Jacob, and *Gaudryceras* cf. *œolum* (d'Orbigny).[3] The latter two would be expected to occur in the German *strombecki* beds of Leymeriellan age, not the *ewaldi* zone (Parahoplitoidan age). Though Professor Judd was right, therefore, in assuming a great unconformity at the top, as at the base of the Speeton Clay, the sequence of events between the Lower Aptian and Upper Albian was probably far more complex than is generally believed. It seems evident, however, that about 800 feet of Aptian beds in the Isle of Wight are unrepresented at Speeton, and that, although there was a Lower Gault transgression, the Albian succession of Speeton is as incomplete as the Aptian.

V. Palæontological Notes.

The desmoceratid genera here mentioned will be discussed in more detail in the Monograph of the Ammonoidea of the Gault, but it may be useful to review here the Crioceratids of

[1] Spath, loc. cit., *Summary Progress*, 1923, p. 147.
[2] Loc. cit., 1889, Diagram section, fig. 8, p. 618.
[3] This was determined as " *Hoplites* ? " by Dr. A. v. Koenen (M.P.G. 17043).

the Speeton Clay and their classification, also that of certain Olcostephanids and Hoplitids.

The earliest British Crioceratids of the Lower Hauterivian beds D_2 and D_1 are referred to *Distoloceras*, and are merely uncoiling forms of the group of *D. hystrix* (Phillips). No representative of the Valanginian group of "*Crioceras*" *curvicosta* v. Koenen, for which the new genus **Juddiceras** g.n.[1] is proposed, has yet been found at Speeton, and it may be added that the *terscissus* group of *Dichotomites*, which are contemporaries of *Juddiceras*, is also apparently absent in Yorkshire.

The true *Crioceras*, with two types of costæ, are found chiefly in beds C_8 and C_7. They are probably partly derived from *Lytoceras*, partly connected with Desmoceratids (and thence *Phylloceratidæ*) by way of *Spitidiscus*, whereas the first two Crioceratid types discussed above belong to the "family" Neocomitidæ, that is to say, they are connected with *Neocomites* and allied genera by morphological transitions and close association in date of existence. The true Hauterivian *Crioceras* do not, however, at Speeton include forms identical with the well-known *Crioceras duvali* and *C. villersianum* d'Orbigny. They are associated with numerous capricorn forms, here referred to the new genus *Ægocrioceras*, with forms of the type of *Ægocrioceras seeleyi* (Neumayr and Uhlig) as transitional links.

In upper C and lower B *Hoplocrioceras* is common. The bundling of the ribs at the umbilical tubercle is similar to that found in *Ammonites mortilleti* (Pictet and de Loriol), with which these forms of the *fissicostatus* group had been identified by Judd. The *Pseudothurmannia*[2] of the *angulicostatus* zone of the South of France may represent the Hoplitid stock from which sprang these Crioceratids. *Uhligia* v. Koenen (*minutus* group), which is probably a "degenerate" Hoplocrioceratid, is not known from Speeton.

Paracrioceras of the Lower Barremian is characterized by highly tuberculate ornamentation and includes also the Mediterranean *emerici* group, whereas its probable derivative *Pseudocrioceras* (*abichi* group) comprises forms with trituberculation tending to appear also on the finer intermediary ribs and much more massive whorls.

In the Snettisham Clay, *Paracrioceras* is associated with another member of the Crioceratidæ, namely *Acrioceras* (*tabarellii* group), but Kilian,[3] no doubt in error, has recorded this also from the Aptian of the Paris Basin. On the other hand, **Lytocrioceras** gen. nov. for

[1] Genotype: *Crioceras curvicosta* v. Koenen, loc. cit., 1902, p. 326, pl. l, fig. 1.

[2] With **Hemihoplites**, gen. nov. (genotype: *Ammon. ferarudianus*, d'Orbigny) and **Metahoplites**, gen. nov. (genotype: *Hoplites henoni* [Coquand] Sayn) included in Hemihoplitidæ.

[3] In Frech, "Lethæa Geogn.," ii. Mesoz. 3. Kreide, pt. i, Unter-Kreide, fasc. iii, 1913, p. 351.

the group of *Ancyloceras jauberti* Astier,[1] including loosely coiled and finely ribbed forms that may represent extreme modifications of the Hauterivian Crioceratidæ and lead to "*Hamulina*" and "*Ptychoceras*" types, is not represented at Speeton, nor are the various Barremian Heteroceratidæ, including *Heteroceras* (with one possible exception), *Atopoceras*, *Dirrymoceras*, *Hemibaculites*, and *Lindigia*. Ancyloceratid or other types of coiling, common after the Hauterivian, are not considered of generic importance, but it will be seen that the sharp distinction between "hoplitid" *Crioceratidæ* and lytoceratid "*Macroscaphitidæ*" cannot be upheld.[2]

The "degenerate" *Paracrioceras* of the *robustum* and *denckmanni* types, occurring in "Cementstone" nodules, have not yet been found "in place" at Speeton. But the Aptian Ancyloceratid genera of Upper B include *Parancyloceras*, established for the *bidentatus-ægoceras* group, with very characteristic costation, and *Toxoceratoides* for the trituberculate *royeri* group. The group of "*Ancyloceras*" *rude* v. Koenen, for which the new genus *Hemicrioceras* is proposed, is represented only by a form that is apparently new; but *Crioceras deeckei* Favre,[3] which has been compared to "*Ancyloceras*" *rude*, is quite distinct, and probably much earlier, and requires a new generic designation: **Peltocrioceras** gen. nov.

The true *Ancyloceras* (*matheronianus* group) is represented in the Hunstanton Carstone, but, like *Leptoceras*, more doubtfully at Speeton, and *Helicancylus* and *Tonoceras* are altogether absent. *Ancyloceras matheronianum* (d'Orbigny) itself occurs in the *Perna* Bed of Atherfield, but this has not yielded *Parahoplitoides bodei*, common at Speeton and in the Carstone of Hunstanton. The still later Lower Greensand genera *Tropæum*[4] (*bowerbanki-gigas* group), *Ammonitoceras* (*transcaspius*[5] group), and **Tonohamites** gen. nov. for *Hamites decurrens* (Roemer) v. Koenen[6] also do not occur at Speeton. On the other hand, there are some Gault Hamitids (*Anisoceras*) in the Museums of York and Hull, but their mode of preservation and association with, e.g. Cambridge Greensand specimens, make it desirable to await confirmation of their occurrence at Speeton.

[1] *Cat. descript. Ancyloceras*, 1851, p. 25, pl. ix, No. 17 (holotype: B.M. 46882).

[2] Spath, "Notes on Ammonites": Geol. Mag., N.S., Dec. VI, Vol. VI, 1919, pp. 30, 220.

[3] "Die Ammon. d. Unt. Kreide Patagoniens": *N. Jb. f. Min.*, etc., Beil.-Bd. xxv, 1908, p. 636, pl. xxxvi, f. 4; pl. xxxvii, f. 1.

[4] On a former occasion (Spath, "Cret. Ammon. Angola": *Trans. Roy. Soc. Ed.*, vol. liii, pt. i, 1922, p. 111) included in *Parahoplitidæ*, with *Ammonitoceras*, but they are probably independent *Lytoceras* (*Cicatrites*) derivatives.

[5] Sinzow, "Untersuch. einig. Ammonitiden aus dem Unt. Gault Mangyschlaks, et.": *Verh. Russ. K. Min. Ges.* (II), vol. xlv, 1907, p. 510, pl. vi, figs. 9–12.

[6] Loc. cit., 1902, p. 392, pl. xxxiii, fig. 3, from the Aptian of Ahaus, which was wrongly placed by Stolley (loc. cit., 1908, p. 220) *below* instead *above* the *deshayesi* zone.

Of importance for correlation is the discovery, in bed D_2 at Speeton, of the baculoid genus *Bochianites*, which is widely distributed, from Europe to South Africa and the Himalayas on the one hand, and to Colombia on the other. It may be considered a straightened-out Neocomitid of the *Juddiceras* type, rather than a derivative of the Tithonian **Protancyloceras** gen. nov. (for *Ancyloceras gümbeli* Oppel [1]), which appears to produce *Bochianites*-like developments.[2]

To show the diversity of the heteromorphous Ammonoidea occurring at Speeton, it may be advisable to list them in the following summary :—

Fam. NEOCOMITIDÆ : *Distoloceras* Hyatt ; *Bochianites* Lory.

Fam. CRIOCERATIDÆ : *Crioceras* Leveillé ; *Ægocrioceras* nov. ; *Paracrioceras* nov. ; *Pseudocrioceras* nov. ; *Acrioceras* Hyatt.

Fam. HEMIHOPLITIDÆ : *Hoplocrioceras* nov.

Fam. HETEROCERATIDÆ : (?) *Heteroceras*.

Fam. ANCYLOCERATIDÆ : (?) *Ancyloceras* d'Orbigny ; (?) *Leptoceras* Uhlig ; *Parancyloceras* nov. ; *Toxoceratoides* nov. ; *Hemicrioceras* nov.

Fam. ANISOCERATIDÆ : (?) *Anisoceras* Pictet.

Apart from the uncoiled forms, ammonites at one time included in "*A. astierianus* d'Orbigny" often cause difficulty in identification. Professor Judd was right in putting his "*astieri* zone" (D beds) below the "*noricus* zone" (lower C), but he may have applied the term "*astieri*" also to the far commoner Polyptychitids. The main development of *Olcostephanus*, of which *A. astieri* is the genotype, is at the base of the Hauterivian and uppermost Valanginian ("*Astieria* Marls" and "*verrucosus* zone" of southern equivalents). The ammonites of these horizons, with very rare *Olcostephanus*, are found at Speeton as phosphatic casts in bed D_2, but associated already with *Lyticoceras noricum*.

Professor Pavlow's "*Astieria*", on the other hand, include, in addition to some doubtful *Olcostephanus*, that may be transitional from the earlier *astieri*-group, a well-defined assemblage of small forms for which the new genus *Subastieria* was proposed. This *sulcosus*-group is characterized by its highly coronate whorls, and *Parastieria peltoceroides*, hitherto confused with the Cenomanian *Acanthoceras*, is an extreme development of *Subastieria sulcosus*, very distinct also from *Valanginites* (group of *A. perinflatus* Matheron) and from *Rogersites* gen. nov. (genotype : *Olcostephanus modderensis* Kitchin [3]). The latter develops gigantic sphærocones

[1] In Zittel, "Die Fauna der Älteren Cephalopoden-führenden Tithonbildungen" : *Palæontogr. Suppl.*, 1870, pl. xii (xxxvi), figs. 1*a–c*.

[2] Kilian (loc. cit., 1910, p. 187) quotes *Bochianites* in the fauna of the "*boissieri*-zone", which includes several Infravalanginian and Tithonian horizons, to judge by Kilian's lists.

[3] "The Invertebrate Fauna and Pal. Relat. of the Uitenhage Series" : *Ann. S. Afr. Mus.*, vol. vii, pt. ii, 1908, p. 202, pl. x, fig. 3.

before *Olcostephanus astierianus* becomes dominant, and is probably represented from Speeton by a small pyritized example, doubtfully compared to v. Koenen's "*Astieria*" *convoluta*,[1] and much closer to the South African group of *Rogersites atherstoni* (Sharpe) than Pavlow's figured specimen of this species, here renamed and referred to the genus *Subastieria*.

Simbirskites Pavlow, here restricted to the original coronate forms of the *decheni* group, is a later stock, again simulating the earlier Olcostephanidæ, and it may be recalled here that various Himalayan and Mexican forms of the genus *Grayiceras* Spath, of the Tithonian, have been wrongly referred to *Simbirskites* as well as Craspeditids and, e.g., what appears to be a Kimmeridgian *Rasenia*.[2]

It seems desirable to separate from *Simbirskites* s.s. the perisphinctoid early forms (*Speetoniceras* gen. nov., genotype: *S. subbipliciforme* nov.[3]), which show that the family Simbirskitidæ probably represent an independent branch of a ribbed Desmoceratid ("*Saynella*") stock. *Simbirskites*, via compressed forms of the group of *S. concinnus* (Phillips) and *S. speetonensis* (Young and Bird), is connected with the discoidal shells of *Craspedodiscus* nov., with *C. clypeiformis* Judd non d'Orbigny,[4] as the final, oxycone, stage. The discoidal branch persists later (to base of B) than the coronate group (ending in C). *Craspedodiscus weerthi* (v. Koenen) has some resemblance to *Neocraspedites tenuis* (v. Koenen), which is a development of the earlier family Polyptychitidæ. To judge by a Val de Travers example before me (B.M., No. C. 23192) of a new species allied to Pictet's specimens[5] of d'Orbigny's *A. carteroni*, included in "*Craspedites*" by e.g. Kilian[6] and Baumberger,[7] this group forms a further, unnamed, genus of the same family.

With regard to the hoplitid forms, the genus *Acanthodiscus* Uhlig is here restricted to the *radiatus* group, but only a few small forms are known from Speeton. This restricted *Acanthodiscus*, with its allies *Lyticoceras*, *Distoloceras*, *Leopoldia*, etc., may be included in a "family" Neocomitidæ, and is widely separated from a somewhat homœomorphous Berriasellid development, namely, *Protacanthodiscus*, established for the group of "*Hoplites*" *andreæi*. It is also necessary to separate from the restricted genus *Acanthodiscus* the group of *A. raimondi* Gabb = **Raimondiceras** gen. nov.,[8]

[1] Loc. cit., 1902, pp. 146, 412, pl. xxxix, fig. 4.

[2] In Skeat and Madsen, "On Jurass. Neocom. and Gault Boulders, etc.": *Danmarks Geol. Unders.* (II), No. 8, 1898, p. 194, pl. vii (*Olcostephanus* cf. *kleini*, Neum. & Uhlig).

[3] *Olcostephanus* [*Simbirskites*] ? sp. in Danford, loc. cit., 1906, pl. xii, fig. 3. See above, under II.

[4] See Lamplugh, loc. cit., 1896, p. 210.

[5] In Pictet and Campiche, *Ter. Crét. Ste. Croix*, 1860, p. 294, pl. xlii.

[6] In Frech, "Lethæa Geogn.," ii. Mesoz. 3. Kreide, pt. i, Unter-Kreide, fasc. ii, 1910, p. 210.

[7] Loc. cit., pt. v, 1908, p. 32.

[8] Genotype: *Hoplites* juv. *raimondii* (Gabb) in Lisson, *Geol. de Lima*, 1907, p. 41, pl. v, fig. 1.

with grooved, not flattened or convex periphery and strongly projected secondary ribs; further, **Octagoniceras** gen. nov., for the group of *Ammonites octagonus* (Strachey MS. Blanford),[1] more nearly allied to the Tithonian *Protacanthodiscus*, but with much more massive ornamentation.

Oosterella, a contemporary of the large Lower Hauterivian *Acanthodiscus*, is unknown from Speeton, as is **Pseudoosterella** gen. nov. for the group of "*Mortoniceras*" *fischeri* Nicklès,[2] and **Suboosterella** gen. nov. for *A. heliacus* d'Orbigny.[3] The latter stock, to judge by examples labelled *A. moutonianus* and *A. ixion* d'Orbigny in the Astier Collection (B.M., No. 73663, 73644), leads from the hoplitid ancestors to these keeled forms of *Oosterella*, but *Lyticoceras cryptoceras* (d'Orbigny), often confused with *Suboosterella* of the *salevensis* type, is also close, as is *Saynella*, the type of which (*S. clypeiformis* d'Orbigny sp.), like certain *Leopoldia*, however, represents a "catagenetic" offshoot.

Of the forms generally confused with *Neocomites* (*neocomiensis* group only) and *Lyticoceras*, here adopted for the group of *A. noricus* Schlotheim, to which d'Orbigny's *A. cryptoceras*, Hyatt's genotype, probably belongs, the group of *Neocomites calliptychus* Uhlig has to be separated with a new name, **Calliptychoceras** gen. nov.,[4] and the new genus **Odontodiscoceras** is proposed for *Neocomites odontodiscus* Uhlig.[5] The former is characterized by its development, unlike that of *Sarasinella*, proceeding from fine to coarse; the latter differs from both *Neocomites* and *Lyticoceras* in peripheral aspect and costation.

Burckhardt[6] restricted *Steueroceras* Cossmann (= *Odontoceras* Steuer) to the early forms of the "*boissieri*" zone; but the type *St. transgrediens* (Steuer)[7] is a Neocomitid of the "*radiatus* zone", and distinguished from *Neocomites* itself by the ventral furrow and specialized outer whorl, and from *Odontodiscoceras* also by its costation, whereas *Lyticoceras*, apart from a different periphery, has more strongly flexiradiate costæ than any of these Neocomitids. *Odontoceras malarguense* Steuer, of the zone of *Spiticeras damesi*, is not

[1] In Salter and Blanford, *Pal. Niti.*, 1865, p. 83, pl. xii, figs. 2*a*, *b*, holotype B.M., No. C. 5032.

[2] "Rech. Géol. Province Alicante, etc.": *Ann. Hébert*, vol. i, 1892, p. 191, pls. vii, viii.

[3] *Pal. Franç., Ter. Crét.* (I), 1841, p. 108, pl. xxv, figs. 1, 2. (The "subcarinate" venter is poorly illustrated.)

[4] Loc. cit. (Spiti Shales, pt. ii, 1910), p. 251, pl. lxxxvii, fig. 2.

[5] Ibid., p. 256, pl. lxxxv, fig. 1.

[6] Loc. cit., 1912, p. 163. The type of *Steueroceras*, namely *St. transgrediens* (Steuer), was erroneously considered to be an *Aulacostephanus*, which, however, includes "*Odontoceras*" *anglicum* Steuer.

[7] Cossmann (*Revue Crit. Pal.*, ii, 1898, p. 115) and Uhlig (*Spiti Shales*, 1910, p. 156) had already restricted Steuer's genus to "*Odontoceras*" *anglicum* and "*O.*" *transgrediens*. The first, an *Aulacostephanus* from the Kimmeridge Clay of Weymouth, was erroneously compared to the Argentine forms, so that "*O.*" *transgrediens* remains as the genotype.

related to *Steueroceras*, but represents a new stock, for which the name **Argentiniceras** gen. nov.[1] may be proposed. The topotypes of Steuer's species in the British Museum,[2] showing bundling of ribs on the inner whorls, make appear probable the connexion of *Argentiniceras* with certain Spiticeratid forms, e.g. *Himalayites mutatus* (Steuer), rather than the somewhat similar forms of Berriasellids (e.g. *Substeueroceras*).

With regard to the use of family names for ammonites, the reader is referred to previous papers.[3] I hold that the fundamental family *Phylloceratidæ*, with Lytoceratids, has continuously, throughout Jurassic and Cretaceous times, replenished the ammonite tribes and that, say, Hoplitidæ and Neocomitidæ are not derived from Berriasellidæ, any more than these originate in some previous Perisphinctid family. It is convenient to include in the family Olcostephanidæ a group of genera such as *Rogersites*, *Subastieria*, and *Parastieria*, that range themselves besides *Olcostephanus*, but it would be rash to assume a monophyletic origin of even this small family in Polyptychitidæ, or of the latter in the still earlier Spiticeratidæ, though these three families replace one another in time and are connected by morphological transitions.

When the true relations of every trachyostracous ammonite to the two persistent root-stocks of *Phylloceratidæ* and *Lytoceratidæ* have been determined, on the basis of careful zonal collecting and uninfluenced by erroneous views of "recapitulation", the present more or less arbitrary classification of ammonites may give way to a fundamentally different scheme. But already we can recognize the essential simplicity of ammonoid phylogeny, which makes appear a master-stroke the first subdivision, by Suess, of all post-Triassic forms into only three groups: *Phylloceras*, *Lytoceras*, and *Ammonites*.

[1] Genotype: *Odontoceras malarguense* Steuer, "Argentin. Jura-Ablag.": *Pal. Abh.*, N.F., iii, pt. iii, 1897, p. 55, pl. xx, figs. 1–3.

[2] B.M., Nos. C. 11204–5.

[3] See "Blake Collection of Ammonites from Kachh, India": loc. cit., 1923, and "Ammonites from New Zealand": loc. cit., 1923, p. 292.

REVIEWS.

THE ORE MAGMAS: A Series of Essays on Ore Deposition. By J. E. SPURR. 2 vols., pp. 915, with 175 figures. New York and London: McGraw-Hill Book Co. Inc., 1923. Price 40*s*.

THE author of this book has long been known as one of the foremost authorities in the United States on the geology of ore-deposits, and during his professional career he has had unrivalled opportunities of studying the subject at first hand, especially in the mining camps of the western States and Mexico, though his experience is by no means confined to these regions. In consequence, he has developed certain definite ideas on the genesis and formation of ore-bodies, as set forth in these handsome volumes. Mr. Spurr was one of the first to call attention to the zonary arrangement of metallic compounds that is often traceable in highly mineralized areas, and has formulated a definite order in space and time, founded on observation. This order, as developed in the United States, has also been found closely applicable in other regions, as for example in Cornwall, where the similarity is very close: this is not an isolated example, and the rule seems to be of very general application. It is undoubtedly founded on a sound physico-chemical basis of temperature and pressure.

Mr. Spurr is a very strong upholder of the magmatic origin of primary ore-deposits, which he regards in all cases as differentiates of igneous masses, the term magmatic being interpreted in the broadest sense, to include for example heated siliceous waters, such as deposit gold-quartz veins. It is in point of fact quite impossible to distinguish between magmatic and hydrothermal conditions, as some writers have tried to do, and it is now extremely doubtful whether any primary ores can be attributed to meteoric waters, that is to water which has ever been at the earth's surface, or in the atmosphere. It would be almost justifiable to state dogmatically that all truly *primary* ore-deposits are due to *juvenile* water, in the sense of Suess. This statement will doubtless still be disputed by some, but in all probability it will eventually be universally accepted, though perhaps incapable of direct proof.

Another important subject discussed in this book is as to the manner in which ore-magmas and magmas in general are introduced into their present situations, with special reference to veins and dykes. For the more pegmatitic varieties of veins Mr. Spurr uses the term "veindike", and he considers that the majority of veins at any rate did not fill open fissures, but themselves pushed the walls apart by gas-pressure. In fact he attributes the highest degree of importance to gaseous tension as an agent, not only of intrusion, but of faulting and earth-movements in general. He pictures, for example, the uprise of mountain ranges, such as the American Cordilleras, as due to the creep of subcrustal magma

from the Pacific basin. He states, "therefore, in the broadest sense, I refer practically all crustal movements to magma migration" (p. 15).

It is doubtful to what extent geologists in general will be prepared to accept this sweeping generalization: it will have to be considered in the light of modern tectonic theories, but at first sight it seems to be consistent with some ideas recently put forth by Professor Joly as to the swelling of the basaltic crust stratum as a result of radio-activity. It is well known that metalliferous mineralization is closely correlated with crustal revolutions, though rather with granitic than with basaltic eruptions, so far as our present knowledge goes. If, however, we are to regard granitic magmas merely as partial differentiates of basalt, this difficulty is diminished. It may be observed here parenthetically that if, as stated on experimental evidence, all silicate melts are completely miscible in all proportions, we have as yet no explanation of why there is in nature such a clear-cut separation into acid and basic magmas, granite, and basalt, coupled with a comparative scarcity of intermediate types, such as might be expected to preponderate if all melts were uniformly soluble in each other.

Other important subjects discussed in these so-called essays, which are more of a connected treatise than might be gathered from the title-page, are the time relation between rock-intrusion and ore-intrusion, epochs of ore-deposition, and metallographic provinces. For this last-named conception the term metallogenetic is preferable, since metallography has another and quite different significance. It is also shown that ores may be regarded on broad lines as belonging to three general types, correlated with acid, intermediate and basic intrusions respectively. The non-metalliferous mineral veins also show definite relationships, certain gangues tending to accompany certain metals and rocks and showing in consequence also regularities of arrangement in space and sequence in time. Many other questions are also discussed in a way that is illuminating and suggestive. Even if it is not always possible to agree entirely with the author's conclusions on certain points, it may well be said that he has provided much food for reflection for those interested in this fascinating subject, which, although for long receiving in America the attention it deserves, has not yet gained full recognition in this country as one of the main branches of theoretical petrology, possessing also the special attractiveness, in many cases, of valuable practical applications.

R. H. R.

Bulletin of the Geological Society of China. Vol. i, 4 parts, and vol. ii, parts 1 and 2. Peking, 1922.

THE Geological Society of China was started in Peking on 27th January, 1922, with twenty-six charter members: since that time a considerable number of fellows and associates have

been elected. Copies of the earlier parts of the Bulletin, just received, give evidence of great activity in geological research. Besides reports of the proceedings at the meetings and titles and abstracts of the papers read, the Bulletin contains several important papers printed in full. Some of these we intend to notice in detail at a later date. Among them are the following:—The New Petrology, by C. P. Berkey; The Sinian System, by A. W. Grabau; The Tsinan Intrusive, by G. B. Barbour; The Upper Cambrian of Kaiping Basin, by Y. C. Sun; and a paper by J. S. Lee on a stratigraphical break in the Cambro-Ordovician limestones of Northern Anhui and its bearing on the classification of the strata of these systems.

Nickel Ores. By W. G. Rumbold. Imperial Institute Monographs on Mineral Resources. pp. 81, with one map. London: John Murray, 1923. Price 5*s*.

As is well known, there are at the present time only two areas producing nickel ores in quantity, namely, Sudbury in Ontario, and New Caledonia, and of these the first-named is by far the most important. Nevertheless, nickel is a metal of wide distribution in small quantities, and Vogt has called attention to the curious fact that nickeliferous sulphides are almost invariably associated with rhombic pyroxenes, in norites, whereas the sulphides found with gabbros carry iron and copper alone. The reason for this limitation is yet to be determined.

In this useful publication the author has summarized in handy form the present state of knowledge of the occurrence of nickel ores throughout the world, with the usual bias in favour of the British Empire. With regard to the origin of the Sudbury ores, the magmatic differentiation theory is accepted in a general way, the segregation being attributed mainly to gravity. It may here be suggested that geologists have not given quite sufficient consideration to the hypothesis of two-phase differentiation dependent on the principle of limited miscibility of sulphides and silicates, a theory which is applicable to many other occurrences of sulphides in association with basic igneous rocks, and founded on the basic principles of matte smelting.

The important deposits of nickeliferous iron ores of the Mayari district in Cuba are briefly described: the value of these for the manufacture of Mayari natural chrome-nickel-steel is perhaps hardly sufficiently recognized.

Die Kohlenlagerstätten Russlands und Sibiriens. By S. von Bubnoff. pp. viii + 244, 30 figures. Berlin: Borntraeger, 1923.

This valuable monograph, although written very largely from the economic standpoint, nevertheless gives a clear and concise account of present knowledge of the geology and tectonic relation-

ships of the coal-fields and possible coal-fields of Russia and Siberia. The author sketches clearly the essential differences in character that exist between the Carboniferous strata of western and eastern Europe, and insists on the fact that coal-formation recurred at frequent intervals during Mesozoic and Tertiary times, while geological conditions were entirely different in the two regions. Hence arise such anomalies to the western mind as Carboniferous lignites and Mesozoic anthracites.

At the present time only the Donetz basin is an effective producer: here the coals lie in the lower part of the Upper Carboniferous, C_2 and the lower part of C_3 of the classification here adopted, equivalent to the lower barren and productive horizons of the Ruhr. Incidentally, it may be remarked that the old divisions of Gshellian, Moscovian, etc., seem to have been thrown overboard under Bolshevik rule. In the Moscow basin, on the other hand, the productive seams are in the Lower Carboniferous, at about the horizon of *Productus giganteus*, the Upper divisions with *Spirifer mosquensis* being represented partly by limestones, and in part missing. In the western Urals coals come at the same low horizon, all the rest being apparently limestones.

Space will not allow of any detailed reference to the later occurrences of coal, none of which appear likely to be of very great practical importance, though useful locally.

On a fossil Filamentous Alga and Sponge-Spicules forming Opal Nodules at Richmond River, N.S.W. By Frederick Chapman, A.L.S. Proc. Royal Soc. of Victoria. Vol. xxxiv, part 2. pp. 167–71, 2 text-figures. 1922.

Common opal from the diatomaceous deposits of the Richmond River, N.S.W., show in one section a spicule-rock originating from freshwater sponges of *Spongilla* and of *Meyenia* type, and in the other remains of a matted, filamentous weed, reminding one of the threadlike confervæ of lakes and streams, cylindrical and constricted at nodes.

REPORTS AND PROCEEDINGS.

Edinburgh Geological Society.

17*th October*, 1923.—Mr. David Balsillie, B.Sc., F.G.S., F.R.S.E., President, in the chair.

"Two Unrecorded Volcanic Vents on the Shore east of North Berwick." By T. Cuthbert Day.

Mr. Day said the part of the coast lying to the east of North Berwick was well known to geologists to whom the study of the great development of volcanic ash on the shore, which stretches inland where it is concealed by surface deposits, had always proved of great interest. Various explanations of the facts observed had

been put forward; but it had not been recognized till now that two clearly defined ancient volcanic vents of very considerable size had pierced the older ash. It was shown by the evidence on the ground that the presence of these two vents was established by the following facts:—

1. The ease with which a definite margin, displaying the usual phenomena, could be traced.
2. The marked difference, on close examination, between the agglomerate and its contents within the vents and the ash outside their margins.
3. The character of the ejected igneous blocks, which were special for each vent.
4. The dipping inwards at certain points of the stratified ash outside the vents as their margins are approached.

The larger volcanic vent occurs at a place named Partan Craig, it is over one-third of a mile in diameter, occupying a large area on the shore, and underlying that part of the eastern golf links known as the Rugged Knowes. The lesser vent, about 270 yards in diameter, is situated at the Yellow Man, a very rocky part of the shore somewhat further to the east. It may be regarded as a singularly good example of an ancient volcanic vent. In both vents a considerable number of cornstones, of the Upper Old Red Sandstone, were found. That these two volcanic vents, which closely resemble similar vents to be seen on the Fife coast between Elie and St. Monans, should have remained so long undiscovered is owing to the fact that their presence is masked by the large amount of older volcanic material round about them.

Mineralogical Society.

6th November (Anniversary Meeting).—Dr. A. Hutchinson, F.R.S., President, in the chair.

Dr. L. J. Spencer: Euclase and platinum from diamond-washings in British Guiana. Small disks resembling fossil corals consist of a radial aggregation of euclase crystals so arranged that the plane of symmetry is always parallel to the surface of the disk. These, together with tourmaline, diamond, gold, and platinum, were found in the conglomerates near the Kaieteur Falls on the Potaro River. Platinum has not hitherto been recorded from British Guiana.

Harold E. Buckley: Some anomalous optical properties of freshly prepared mixed crystals of the Seignette salts. In the orthorhombic and isomorphous Seignette salts the sodium-potassium tartrate has the optic axial plane parallel to the brachy-pinacoid, whilst in the sodium-ammonium salt it is parallel to the macro-pinacoid. Mixed crystals of the two salts show, as would be expected, the optic axes for different colours in two planes at right

angles (as in brookite), but only after the crystals have been prepared for some time. Freshly prepared mixed crystals exhibit crossed dispersion of the monoclinic type (as in borax). A maximum angle of 75° between the axial planes for red and violet light is given by crystals containing 45 per cent Na-K tartrate. On standing, the axial planes slowly migrate to the planes of symmetry, and equilibrium is established in from two to thirteen weeks, this being hastened by increasing the temperature.

Colonel N. T. Belaiew: On the genesis of Widmanstätten structure in meteorites and in terrestrial alloys. The Widmanstätten structure belongs to the triad of secondary structures, the other two being the structure of large crystals and the network structure. Under suitable conditions, either of these structures may occur in iron-carbon alloys or in any other alloys, crystallizing in the face-centred cubic lattice and exhibiting the same kind of equilibrium diagram. As the diagram of the Fe-Ni alloys is quite similar to that of Fe-C, the same kind of crystallization may be expected in either case and also in that of meteorites. The well-known Widmanstätten figures in meteorites are also arranged in a Widmanstätten structure. From their appearance an inference can be made as to the conditions of cooling which furthered their appearance. These conditions are a very slow cooling after solidification in the granulation zone, and a relatively rapid separation of the constituents afterwards in the zone of secondary crystallization leading to their lodging themselves parallel to the octahedral planes in every granule.

Professor L. R. Wilberforce: Illustration and detection of inclined and horizontal dispersion in bi-axial crystals. If the optic picture of an ordinary bi-axial crystal is viewed through a prism whose refracting edge is parallel or perpendicular to the axial plane, the appearances characteristic of horizontal and inclined dispersion are respectively produced. Such dispersions in a crystal if too small to be detected by direct observation, can be discovered by thus using a prism of small angle alternately to reinforce and oppose them, and noting the want of symmetry in the effects produced.

Arthur Russell: On the occurrence of the rare mineral nadorite in Cornwall, and of beraunite (eleonorite) in Co. Cork, Ireland. A single specimen of the rare mineral nadorite was found by the writer at the small antimony mine, Bodannon, St. Endellion, Cornwall. The nadorite forms aggregates of nearly square platy crystals, transparent, of a yellowish-brown to reddish-brown colour, occupying a cavity in fibrous jamesonite. The crystals are combinations of a (100) and r (130), and are twinned on l (011). A very well defined specimen of the variety of beraunite known as eleonorite was found by the writer at the iron and manganese mine of Roury Glen, Glandore, Co. Cork. It consists of a mass of diverging fibrous crystals of a reddish-brown colour, between walls of limonite.

been put forward; but it had not been recognized till now that two clearly defined ancient volcanic vents of very considerable size had pierced the older ash. It was shown by the evidence on the ground that the presence of these two vents was established by the following facts:—

1. The ease with which a definite margin, displaying the usual phenomena, could be traced.
2. The marked difference, on close examination, between the agglomerate and its contents within the vents and the ash outside their margins.
3. The character of the ejected igneous blocks, which were special for each vent.
4. The dipping inwards at certain points of the stratified ash outside the vents as their margins are approached.

The larger volcanic vent occurs at a place named Partan Craig, it is over one-third of a mile in diameter, occupying a large area on the shore, and underlying that part of the eastern golf links known as the Rugged Knowes. The lesser vent, about 270 yards in diameter, is situated at the Yellow Man, a very rocky part of the shore somewhat further to the east. It may be regarded as a singularly good example of an ancient volcanic vent. In both vents a considerable number of cornstones, of the Upper Old Red Sandstone, were found. That these two volcanic vents, which closely resemble similar vents to be seen on the Fife coast between Elie and St. Monans, should have remained so long undiscovered is owing to the fact that their presence is masked by the large amount of older volcanic material round about them.

Mineralogical Society.

6th November (Anniversary Meeting).—Dr. A. Hutchinson, F.R.S., President, in the chair.

Dr. L. J. Spencer: Euclase and platinum from diamond-washings in British Guiana. Small disks resembling fossil corals consist of a radial aggregation of euclase crystals so arranged that the plane of symmetry is always parallel to the surface of the disk. These, together with tourmaline, diamond, gold, and platinum, were found in the conglomerates near the Kaieteur Falls on the Potaro River. Platinum has not hitherto been recorded from British Guiana.

Harold E. Buckley: Some anomalous optical properties of freshly prepared mixed crystals of the Seignette salts. In the orthorhombic and isomorphous Seignette salts the sodium-potassium tartrate has the optic axial plane parallel to the brachy-pinacoid, whilst in the sodium-ammonium salt it is parallel to the macro-pinacoid. Mixed crystals of the two salts show, as would be expected, the optic axes for different colours in two planes at right

angles (as in brookite), but only after the crystals have been prepared for some time. Freshly prepared mixed crystals exhibit crossed dispersion of the monoclinic type (as in borax). A maximum angle of 75° between the axial planes for red and violet light is given by crystals containing 45 per cent Na-K tartrate. On standing, the axial planes slowly migrate to the planes of symmetry, and equilibrium is established in from two to thirteen weeks, this being hastened by increasing the temperature.

Colonel N. T. Belaiew: On the genesis of Widmanstätten structure in meteorites and in terrestrial alloys. The Widmanstätten structure belongs to the triad of secondary structures, the other two being the structure of large crystals and the network structure. Under suitable conditions, either of these structures may occur in iron-carbon alloys or in any other alloys, crystallizing in the face-centred cubic lattice and exhibiting the same kind of equilibrium diagram. As the diagram of the Fe-Ni alloys is quite similar to that of Fe-C, the same kind of crystallization may be expected in either case and also in that of meteorites. The well-known Widmanstätten figures in meteorites are also arranged in a Widmanstätten structure. From their appearance an inference can be made as to the conditions of cooling which furthered their appearance. These conditions are a very slow cooling after solidification in the granulation zone, and a relatively rapid separation of the constituents afterwards in the zone of secondary crystallization leading to their lodging themselves parallel to the octahedral planes in every granule.

Professor L. R. Wilberforce: Illustration and detection of inclined and horizontal dispersion in bi-axial crystals. If the optic picture of an ordinary bi-axial crystal is viewed through a prism whose refracting edge is parallel or perpendicular to the axial plane, the appearances characteristic of horizontal and inclined dispersion are respectively produced. Such dispersions in a crystal if too small to be detected by direct observation, can be discovered by thus using a prism of small angle alternately to reinforce and oppose them, and noting the want of symmetry in the effects produced.

Arthur Russell: On the occurrence of the rare mineral nadorite in Cornwall, and of beraunite (eleonorite) in Co. Cork, Ireland. A single specimen of the rare mineral nadorite was found by the writer at the small antimony mine, Bodannon, St. Endellion, Cornwall. The nadorite forms aggregates of nearly square platy crystals, transparent, of a yellowish-brown to reddish-brown colour, occupying a cavity in fibrous jamesonite. The crystals are combinations of a (100) and r (130), and are twinned on l (011). A very well defined specimen of the variety of beraunite known as eleonorite was found by the writer at the iron and manganese mine of Roury Glen, Glandore, Co. Cork. It consists of a mass of diverging fibrous crystals of a reddish-brown colour, between walls of limonite.